VOL. 22 OCTOBER 1961 NO. 4



# FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL



FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 22 Number 4

# FIRE CONTROL NOTES

## A Quarterly Periodical Devoted to the

## TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (October 17, 1958).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1961

# CONTENTS

# FOREST FIRE RESEARCH—THE NATIONAL PROGRAM[1]

GEORGE M. JEMISON
*Deputy Assistant Chief, U.S. Forest Service,
Washington, D. C.*

Joe West, Elk Creek Zone fire dispatcher, sat before the console of the fire control center and listened to the hum of the computers relaying their information to the dials and viewing screens around him. "Some different from the old days," he thought, "but just as hard on the nerves."

He glanced at the automatic typewriter at his elbow clattering out the stream of weather and fuel data coming in from robot measuring stations around the forest. Some scattered lightning predicted. He knew the airborne cloud-seeding generators had been active since early morning but the electrical field metering system showed him that a charge persisted in some localities. This meant a few strikes for sure.

Suddenly, the receiver for the heat-sensing tower network picked up its signal. Before he could turn his head to view the translucent forest map, the computers had done their work and an illuminated spot had appeared in the head of Pine Creek showing the location of the fire. He was glad the technicians had fed up-to-date information into the memory of the machines last week—it saved a lot of false alarms.

Joe automatically activated the television camera on Pine Mountain and on the screen quickly identified the smoke. He zoomed in for a closeup image of the hillside and verified the serious fuel conditions he remembered there. He checked the travel-time computer which reported immediately the time his first crew could arrive at the nearest heliport to be ferried to the fire. Again he thanked the "brain" of the machine which had been storing the radioed position of the work crews every 30 minutes. It had already selected its answer when the spotting mechanism located the fire on the map.

"Rapid initial spread," Joe thought. "Crews too far to rely on manpower alone." He hit the missile-launching lever for the pad nearest the Pine Creek area. As the missiles rose, Joe knew the quadrant guidance system would see that they reached the target area and then let their heat-sensitive noses home them in on the target. By radio, he set the proximity fuses to activate about 50 feet above the ground; that would be about right for the young growth and slash underneath. "Two loads of that new retardant should hold it," Joe thought.

---

[1]Talk presented at Lake States Forest Fire Research Conference, Green Bay, Wis., March 8, 1961.

He radioed his crew, already alerted since the computer automatically signaled them the location of the fire. Nothing like checking on the machines. He filled in the crew on the conditions at the fire and told them the effects of the chemical bursts which he observed as he talked. "Just a routine trip, boys," he concluded as he settled back and punched the time verifier into the automatic daily log. "One minute and forty-two seconds," he mused. "Not bad."

Science fiction? Quite a bit. But not as much as some of you may think. Never before have the opportunities been so great as now for research and the application of scientific knowledge to help us solve some of our most trying forest fire problems. This is why we believe in a comprehensive program of forest fire research. Now, after such a long-winded start, I am going to talk about such a national program.

## DEVELOPMENT OF A FIRE RESEARCH PROGRAM

Formal fire research began prior to 1920 in Western United States but it was about 1923 or 1924 when the first full-time fire research specialist was appointed. In the 1930's research was speeded considerably and approximately 15 men were spending full time and $100,000 a year on a variety of research projects from West to East.

As with most forestry research activities, World War II caused a drop in fire research. Even by 1952 there were still fewer fire research scientists on the job than in the 1930's. Since 1955, however, fire research efforts have climbed steadily until today, Federal, State, and private agencies spend an estimated $1,250,000 a year on fire investigations.

Description of the recent rapid growth of fire research in such material terms, of course, is not the whole story nor does it give us a sound basis for judging what kind of a national fire research program we need. Most of the fire research for the first 30 years was observational and empirical. However, great strides were made even though much progress resulted from a "cream skimming" approach. Look at the benefits that have come from fire danger measurement. Think of the many types of fire control equipment that have been developed. Aerial fire control achievements have been outstanding. The techniques of prescribed burning in many fuel types made rapid progress. Use of chemical fire retardants is one of the more recent and spectacular applications of empirical research results.

As beneficial as such research has been, it is not going to satisfy our needs for the future. If we continue to approach the most critical fire problems of the future with the same empirical methods we have used in the past, we are doomed to fail in bringing fire losses and costs to acceptable low levels. You may consider this to be an extreme point of view. Let us examine it further.

Fires are still causing unacceptable losses in many parts of the United States in some years. The risks to long-term management

are high even in the South, where opportunities for profitable timber production are more advanced than in most other regions. Threats to other resource values, such as watersheds, are in places intolerable. Encroachment of urban developments and the presence of larger numbers of people who use the forests impose mounting handicaps on the fire control organization and add substantially to the difficulty of fire control. Thus, we see fire control costs steadily climbing to new highs every year. But we are still taking 95 percent of our losses from a comparatively few fires. We have not made progress in eliminating what we call the "unusual fire." Somehow we are going to have to learn enough of the why's and wherefor's to enable us to take strides heretofore impossible.

In research circles one can almost always get up a quick argument on definitions of basic and applied research. It is not my intent to start such an argument here. I do firmly believe, however, that future progress in fire control will require a much stronger emphasis than in the past on the more basic aspects of fire problems. Of course, this is not to say we will no longer need good applied research, utilizing fully any empirical approaches that look promising. Such research will continue to pay off. But to the extent we explore new principles and probe into the basic aspects of broad problems, the more productive will be the application phases of new studies. And the more likely we shall be able to solve the problem of meeting the "unusual" situations.

## EMPHASIS IN THE NATIONAL PROGRAM

Then, what kind of research should we be doing in a national program? What should the emphasis be? One could make a long list of fire problems that need attention in such a program. Some of the more important problems are the most difficult and are the ones that we have not adequately attacked heretofore.

Basic research is badly needed to hasten the understanding of forest fire behavior. Knowledge of the combustion process and how various factors influence it is vital to progress in most phases of fire control. There is nothing unusual about the behavior of any fire anywhere. The combustion process is always controlled by environment according to specific physical and chemical laws. We just have not learned to interpret and apply these laws to every situation. When we do understand the factors that control fire behavior we can do a better job of predicting it. Only then can we make any real progress toward whittling down that small but significant group of fires that cause our greatest losses to resources, property, and human life.

Part of this research can be carried on to advantage in the laboratory. Here we can learn basic features of the combustion process and how the many individual factors of environment affect it. We are in this process now. Later through combined laboratory-field studies, scaling laws will be developed. Additional

laboratory fire model studies will be needed to provide methods for predicting such things about fire as its rate of spread, spotting and crowning, and other important features of fire and its behavior in natural environments.

Prevention of man-caused fires has been prominently listed as a field deserving systematic investigation. A case study approach has been tried several times in the past. Only in recent years, however, has there been a serious effort to organize research on segments of the man-caused fire problem in a way that may lead to better answers than we have now. In any national program, greatly accelerated research on people is needed—what motivates them to act or not act in certain ways, how do we change habit patterns, what are the most effective and economical ways to achieve favorable results? We need more research on the effectiveness of all the common prevention measures and the development and evaluation of new ones. So far we have not cashed in on the huge background of knowledge in the social science field which has proved so effective in American advertising and other areas where influencing human behavior is involved.

We should not rule out the possibility of preventing lightning-caused fires. Many of you know about Project Skyfire in the northern Rocky Mountains. Here scientists are studying cloud physics and the development of electric fields in the atmosphere with the hope that ways can be found to reduce the potency of fire-starting electrical storms. At the present time, leads are encouraging but a great deal more basic research is needed.

A strong program of research must be started on chemical fire retardants and suppressants. In the past few years extensive use has been made of chemicals to retard fires and many fire control officers are sold on this method in spite of its high cost. We hope this confidence is not misplaced. But as of today, we have no sound method of evaluating the effectiveness of various retardants in controlling dangerous fires. Little research has been done to establish the conditions, timing, and techniques required for maximum payoff. We do not even understand the principle of the retardant or suppressant action in many cases. A lot needs to be done before we can prescribe the fuel coverage required for effective chemical fire control, the chemical droplet size, viscosity, and equipment best adapted to the use of chemicals.

## EMPHASIS NEEDED ON APPLICATION OF PRINCIPLES

I could go on and on listing specific fields of research that need attention in a national fire research program. But there is one overriding thought that I want to dwell on for a moment. This has to do with *principles* that can be used in fire control.

It is a human tendency to hold more or less rigidly to the ways in which we usually do things. We have set patterns we tend to use in fire control. For example, robbing a fire of its fuel is a standard and effective way to control it. Thus, we try to improve on this method of control by inventing a better fire rake or fire

plow or by using a bigger bulldozer. And I do not slight the great strides we have made through improved fire control equipment, apparatus, and machines. However, we still tend to send men to fires in 200-mile-per-hour airplanes and then give them an ax and shovel to do the job.

As all of you well know, there are three common ways to control a fire: (1) rob it of fuel, (2) cool the fuels below ignition temperature, or (3) exclude oxygen. Application of each of these methods requires energy. What are the various ways that energy can be delivered in time and place using one or more of the fire control approaches? I maintain we have not done a thorough job of examining the physical, chemical, and engineering principles required and available to do the job. How can you rob a fire of oxygen? What kinds of energy would it take? Can ways be found to reduce fuel temperatures? Water, of course, is one way but must it be pumped on in quantities? Are there more efficient ways to use water to contain the fire's energy? And so on and on. We must delve into principles in future research and examine all the newer approaches that such research might turn up.

Musing along these lines brought me to Joe West, the Elk Creek Zone fire dispatcher. Really, I am not talking specifically about all of his gadgets although at least prototypes of every one of them are available today. I do think that our success in meeting necessary future fire control goals will demand imaginative thinking and basic research of a kind we have scarcely begun. The problem of the large or "unusual" fire is not going to disappear. But daring imagination in research will be required to solve it.

The States have recognized that they have a big stake in the fire research field. The State Foresters' Association has passed a series of resolutions recommending a stronger program. Although State forestry organizations are not often staffed to do research themselves, except perhaps in the equipment development field, several States are actively speeding up the research in which they are most interested through joint action under cooperative agreements with the Forest Service and with universities.

Research at State universities has been worthwhile and can be increased especially in some basic physics and chemistry aspects of fire problems. Their social science and psychology specialists can be enlisted in fire prevention research and their engineering departments can contribute in many ways. Private industries have boosted fire research in the past and will continue to do so, especially in perfecting fire equipment.

In the years ahead we are not going to have a truly *national* fire research program unless all responsible agencies and groups —whether they be Federal, State, or private—move ahead on a well-coordinated research program. Such a national program will require good leadership, strong financing, well-trained scientists, good facilities, and worlds of imagination. If we can mix these ingredients wisely and well, we may be recruiting and training a Joe West for Elk Creek before you know it.

## RESPONSIBILITIES FOR FUTURE NATIONAL PROGRAM

Who should participate in a balanced national program of forest fire research? Actually, a national program must be one supported by all agencies and institutions responsible for and equipped to do fire research. Fire is a natural phenomenon but one that is no respecter of political boundaries and ownerships. Hence the Federal Government plays a big role in fire research.

The Forest Service is gradually strengthening its fire research program. We have recognized the need for more emphasis on basic research and have been obtaining better facilities to round out this side of the research program. We now have two large and modern fire laboratories: one at Missoula, Mont., and one at Macon, Ga. The latter was constructed with State funds and is staffed and operated by the Forest Service under a cooperative arrangement. A third fire research laboratory will be started in the near future at Riverside, Calif. While the special equipment, instruments, and facilities available at the three large laboratories will provide for a stepped-up basic research program, applied research will continue and be further strengthened. The Forest Service's fire research program will be expanded at other than the three locations mentioned. For example, we expect to continue to build up a fire research program in the Lake States.

☆ ☆ ☆

## Label the Hydraulic Track Adjustment Fitting

Some of the newer model fire plow tractors are equipped with a hydraulic track tension adjustment. Adjustment is made by applying grease, with a standard hand grease gun, through a standard fitting. This fitting is in plain view, but it cannot be distinguished from other chassis fittings. Therefore, the possibility exists that someone unaware of this will tighten the tracks while greasing the tractor. Tracks that are too tight result in excessive wear of the track rails and rollers. To prevent this from happening, we have lettered "DO NOT LUBE" at the track adjustment fitting. This requires about 5 minutes of time and a small amount of paint, which is cheap insurance to protect a large investment.

An Allen wrench is needed to release the pressure on too tight tracks, and one of these should be carried in the tractor toolbox at all times.—Howard W. Burnett, *District Ranger, Georgia National Forests.*

# SELECTING FIRE CONTROL PLANNING LEVELS BY BURNING INDEX FREQUENCIES[1]

ARTHUR R. PIRSKO
*Forester, Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service*

How do you pick the base level of burning conditions for planning a fire control organization? Hiring and equipping full-time crews to handle the worst possible situation is obviously not economical, since extreme burning conditions occur infrequently. The more realistic practice is to set up a full-time organization adequate for normal or somewhat above-normal burning conditions and then fill in with emergency crews when the situation demands. The planner, knowing his production goals and values he protects, must decide on a cutoff point for the size of full-time and emergency force he can maintain economically. But selecting the point between normal and above normal burning conditions has always been a problem.

Planning concepts for fire control organizations have long been tied to normal burning conditions.[2] Worse-than-average conditions were recognized to exist, but the severity of burning conditions could not be determined until after the fire season. Then, severity was described by the percentage of fires reaching over 10 acres in size and the total area burned in the most difficult years. Show and Kotok[3] stressed the importance of aiming protection effort at controlling fires under average worst conditions, but they had no burning index to serve as a yardstick. More recent fire control planning, as in Canada, relates organization plans to average burning indexes.[4] The problem in planning, though, is to measure above-average conditions.

One method arbitrarily took the "average worst day" as the planning base for "average bad" conditions. The approach was first to select an "average worst year"—defined as the third worst in the last 10 years as determined by the sum of daily burning indexes. Then, for that particular year the average burning index of the worst 15 percent of the days was computed and taken as the base level. Such a base must not be applied too widely. If it is, it may not allow for geographical variations in climate.

---

[1]Issued Jan. 1961 as Pacific Southwest Forest and Range Expt. Sta. Misc. Paper 55.

[2]Dubois, Coert. Systematic fire protection in the California forests. U.S. Dept. Agr. Unnumb. Pub., 99 pp., illus. 1914.

Hornby, L. G. Fire control planning in the northern Rocky Mountain region. U. S. Forest Serv. North. Rocky Mountain Forest and Range Expt. Sta. Prog. Rpt. 1, 179 pp., illus. 1936. (Processed.)

[3]Show, S. B., and Kotok, E. I. The determination of hour control for adequate fire protection in the major cover types of the California pine region. U. S. Dept. Agr. Tech. Bul. 209, 47 pp., illus. 1930.

[4]Beall, H. W. Forest fires and the danger index in New Brunswick. Forestry Chron. 26 (2): 99–144. 1950.

A method of selecting a planning base that will show the probable frequency of a given burning index is reported here. It was devised for use with the California fire danger rating system, in which the burning index is rated on a scale of 0 to 100 and expresses the expected fire spread and intensity as influenced by weather. The index, therefore, is a good measure of relative job size—the higher the index, the more men and equipment will be needed to meet a desired fire control goal in a given period.

The recent revision of the California fire danger rating system[5] showed that an area the size of a national forest could have as many as seven different climatic regimes. When differences in weather, fuel, and topography were considered, the State as a whole had to be divided into 144 fire danger rating areas. Therefore, base levels were computed for fire control planning in each of these areas in the California Region.

The approach chosen was to determine from fire weather records the frequency of occurrence of each burning index. Data used were the daily burning indexes in a 6-year period, for July and August in northern and central California, and for July, August, and September in southern California. Each frequency was expressed as a percent of the total, the percents were cumulated, and the cumulated percents were plotted on arithmetic probability paper.

The resulting charts made it easy to see the frequency of "easy," "normal," or "bad" days. Planning levels can be set to cover a specified percent of the days during a fire season, and the burning index to be expected at this emergency point can be read from the chart. In the California Region, the planning level selected for the fire control organization is 90 percent frequency; the corresponding burning index is called the "area base burning index."

The variability of planning levels can be illustrated by probability curves for four fire danger rating areas (figs. 1–4). In these areas, base indexes range from 12 in the north coast mountains, to 29 in the central coast, and to 17 and 43 in 2 adjacent southern California areas. This means that in the central coast area, for example, 90 percent of the days will have a burning index of 29 or lower, and 10 percent of the days will have a burning index above 29.

Such charts help a planner visualize weather differences between areas. The average burning index, which can be expected half of the time, is not as much alike in adjacent areas as one might expect. In the 2 southern California areas, for example, one averages 11 while its neighbor averages 26. The extreme conditions also differ markedly; in one the burning index is 46, in the other 88.

New charts need not be prepared if management is intensified to increase productivity. As the acceptable fire loss becomes less,

---

[5]Schroeder, M. J. Development of the California fire danger rating system. Amer. Meteorol. Soc. Bul. 39 (3): 178–9. 1958. (Abstract.)

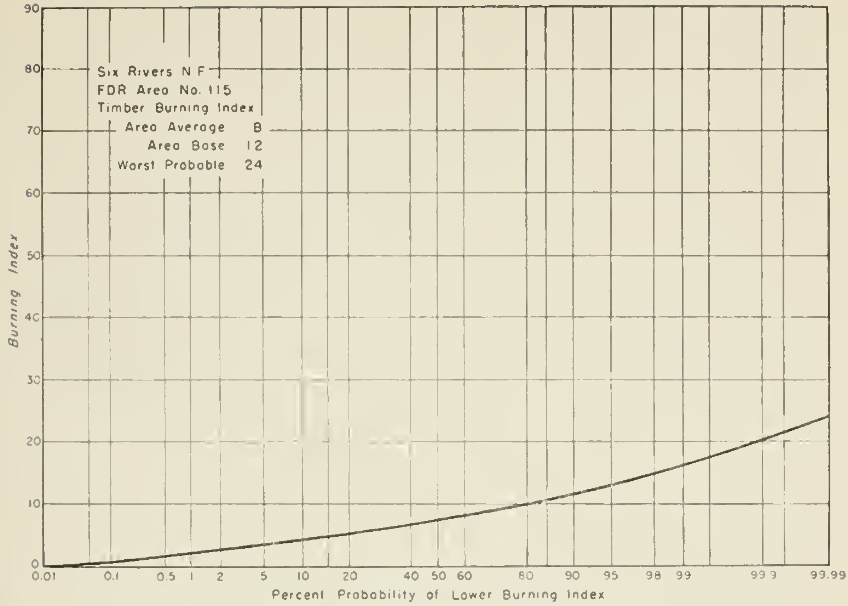



FIGURE 1

the frequency level can be increased—say from 90 to 95 percent—and a new area base can be read from the chart.

Thus, cumulative probability curves give a planner flexibility. He can rate each area on its distinctive weather conditions and

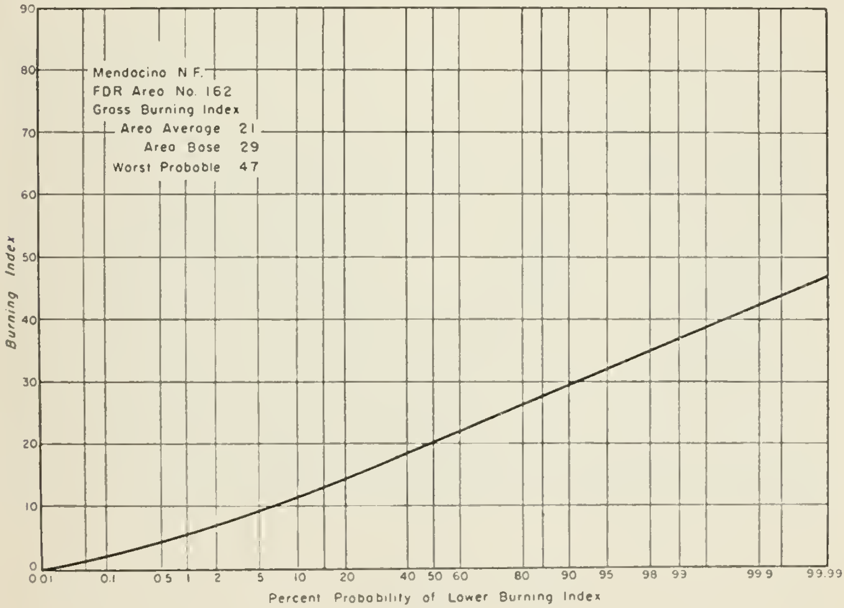



FIGURE 2

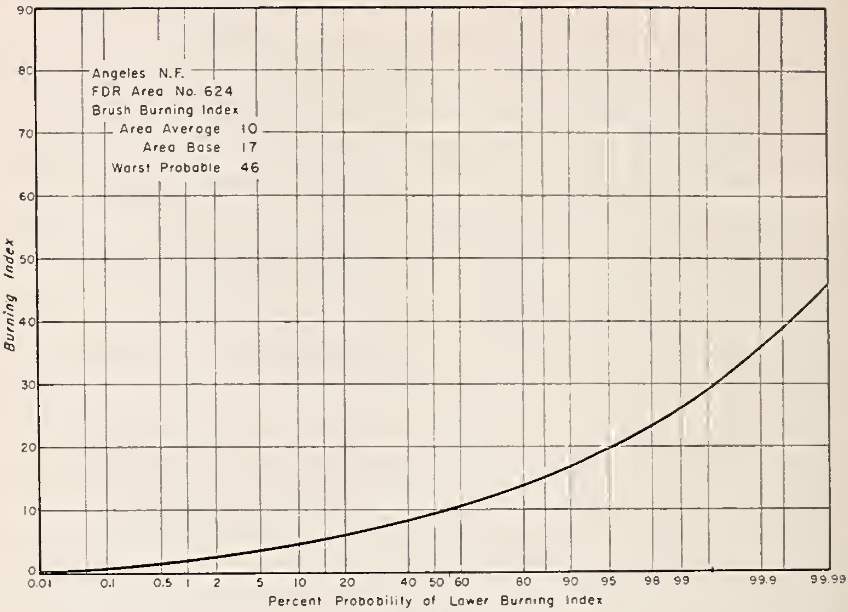



FIGURE 3

easily adapt his organization to future changes in the job load. To produce such curves, good fire weather records are needed, and access to machine data processing is desirable. Frequency analysis by hand computation is a laborious, costly task.

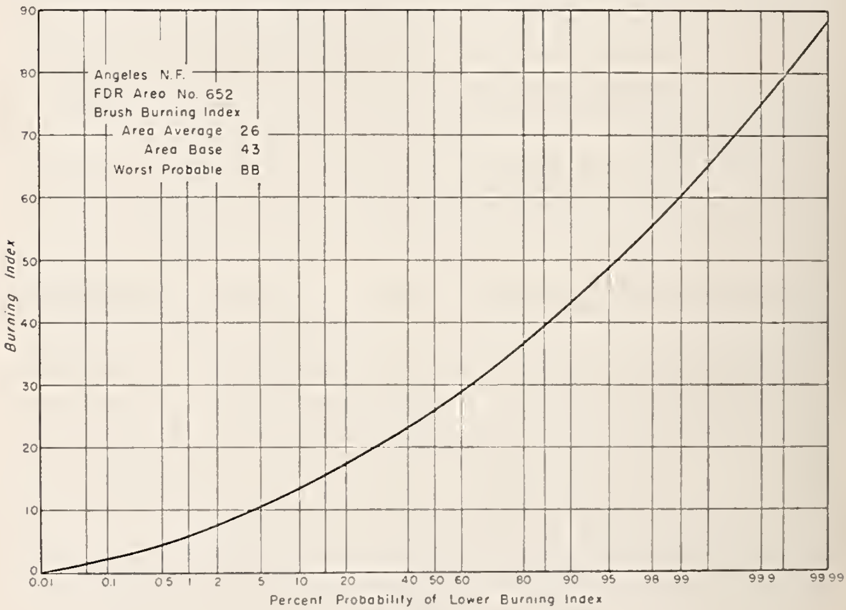



FIGURE 4

# TRACTOR-PLOW UNITS ON APPALACHIAN MOUNTAIN FIRES

ROBERT R. SWIGER
*District Ranger, Cherokee National Forest*

Tractor-plow units have been successfully used for fire control in the South for many years. Development and use were greatly stimulated during World War II when the manpower shortage was keenly felt. Most people felt, however, that the units were for use in the flatwoods and were of little or no value in the mountains. Contrary to popular belief, relatively small tractors with plows can be used efficiently for fire control in the Appalachian Mountains. Such units in operation in Tennesse have proved conclusively that they have an important place in fire control.

The plows presently used with the small tractors are middle-buster-disk type with three point hitch (fig. 1). This plow makes a very clean line about 5 feet wide. In average Appalachian terrain where the plowing is continuous, such a tractor and plow combination will construct about 150 chains per hour. In terrain where the plowing must be interrupted to get the tractor back on top of the ridges to plow downhill, this average may drop to about 45 chains per hour.

It has been determined that the average rate of handtool line construction in the mountains is from 3 to 4 chains per man-hour. This production is gradually reduced as the men tire, whereas the

FIGURE 1.—Tractor with plow in raised position.

plow unit production normally is steady. The hand line is also not as wide nor as clean as that constructed with the plow.

Construction of plowed firelines in the Appalachians differs from that in the flatwoods. Very few of the fires can be controlled by starting in one place and then plowing forward until a complete line has been built at the head or around the fire. In the mountains, steepness of terrain prohibits construction of a plowed line in one direction all the time. On steep slopes the line is constructed downhill whenever possible. In plowing uphill, the line may be started in a favorable location and continued until adverse grade is encountered. Line construction is then discontinued at this point, and the tractor is backed up the slope when necessary, as a safety precaution. It is "deadheaded" up the ridge and put into position to plow down the slope and join into the discontinued line. This means, of course, that the tractor would have to go back up the same ridge again to continue the line for encirclement of the fire.

Under normal conditions it has been found possible to plow safely downhill on slopes up to 65 percent. It is imperative, however, that good scouting precede the tractor-plow unit. On the steeper slopes, if an unplowable area is found, another route must be selected before the tractor starts its descent. Without proper scouting, the plow may get into a situation where it is impossible or unsafe to continue in a forward direction. This might be because of rock ledges, bluffs, thick and large timber, or down logs and snags. It may be impossible to reverse direction and return to the top because of steep ground, loose rocks or rock ledges. Escape to either side will probably also be impossible because of the side slope which would cause the tractor to turn over. The 20-30 hp. crawler tractor-plow units can generally plow safely on a side slope up to 35 percent, as compared with the 65 percent down slope. A mistake in scouting can be time consuming, costly, and dangerous. The scout should be a man capable of operating the unit, and who knows exactly what its limitations are.

An ideal-sized tractor-plow crew for the mountains is three men. Three men can ride in the cab of a plow truck, which means only one vehicle is needed for transportation of the tractor-plow and crew (fig. 2). One man is the operator, one the scout, and the other is the followup man. As mentioned earlier, the scout must be a competent man and preferably an experienced plow operator. He must be able to recognize all the dangers and problems that lie ahead of the plow. The followup man removes any material which is left in the fireline or on turns where the plow is raised. He also helps the tractor operator at any time he is needed, such as when the plow becomes fouled.

There must of course be a followup crew behind the plow crew. They backfire from the fireline and hold it. The size of this crew would depend on factors such as the size of the fire, burning conditions, and type of fuel. One tractor-plow unit could keep as many as 25 followup men busy under some conditions.

FIGURE 2.—Plow unit on truck ready to roll.

In the Appalachians, the terrain is generally rather steep, and there are many areas which have rather heavy concentration of heavy fuel. Because of these features, mopup is normally very heavy. For example, in recent years mopup on the Hiwassee District of the Cherokee National Forest has averaged about 80 percent of the total man-hours spent on fires. Therefore, in areas where manpower is short, as it is in much of the Appalachians, the tractor-plow unit is used in initial attack action whenever possible.

Some mountain fires occur in terrain where plowing is impossible, or where only partial plowing is possible. In his estimate of needed suppression forces the dispatcher must be able to determine if a plow can be used and to what extent. The secret to successful use of the plow, therefore, is a good plowable area map.

For a long time tractor-plow units were used only sparingly in the Appalachians, or not at all, because it was not known what could be accomplished with them. Now that the tractor-plow units have proved that they can reduce the manpower needs in firefighting, they are used each year on a larger percentage of fires in the Appalachian Mountains.

# SAND-THROWING MACHINE FOR FIGHTING FOREST FIRES

STEVE SUCH
*Supervisor, Forest Fire Experiment Station, Michigan Department of Conservation*

Designed and constructed at the Forest Fire Experiment Station, Roscommon, Mich., as a cooperative effort of the State of Michigan and the U.S. Forest Service, the sandthrower is an experimental development to test the effectiveness of sand or loose dirt in suppressing forest fires.

This machine is intended for direct or indirect attack, and it has shown a versatility still not available in other types of forest fire equipment. It is powered by a 130-horsepower industrial engine, operating through a power train to drive the large, vaned disk at the rear of the machine. The disk removes sand or dirt in a continuous motion; hydraulic controls are provided for directing the "stream" to the area requiring action.

The sandthrower moves through the woods at 1 to 2 miles per hour and it is capable of throwing 2 to 4 yards of sand or dirt per minute at velocities approaching 70 miles per hour and trajectories from flat to elevations of 25 feet. Effective distances

have measured from 20 to 50 feet. Fires are quickly extinguished as the mass of sand or dirt comes into contact with the burning fuels.

Future plans call for the design of a self-contained unit mounted on a D-4 crawler tractor. It is hoped that ultimately a simple, powerful, and thoroughly practical machine will be economically feasible.

# CORRELATION OF WEATHER TO FIRE SPREAD IN GRASS AND BRUSH FUELS ON THE SNAKE RIVER PLAINS IN SOUTHERN IDAHO

RICHARD E. TRAYLOR
*Fire Control Aid, Bureau of Land Management*

Rate of spread of fire in different fuels under varying climatic conditions is the key to many fire control decisions. Controlling factors that govern rate of spread for any particular fire are the fuels and the environment, the latter consisting of air moisture, temperature, wind, and other related factors such as barometric pressure.

There are several ways to approach the study of rate of spread of wildfires. One is to base rate of spread on perimeter increase. The second is to use the concept that a fire generally will move in a particular direction. This direction would be the forward spread of the fire. Using this concept, the rate of spread is measured in a forward movement in chains per hour. I based my study on the forward rate of spread, because of the nature of the fuels involved.

The study, designated as "Project Fire Spread," was initiated in the Boise District of the Bureau of Land Management, with headquarters at Boise, Idaho. Data were gathered for the project within a 75-mile radius of Boise during the 1959 and 1960 fire seasons.

"Project Fire Spread" was designed to determine the effects of weather, slope, and fuel types on the spread of wildfires.

The main fuels were sagebrush (*Artemisia tridentata*) and cheatgrass (*Bromus tectorum*). Fuel types were delineated as follows: (1) Sagebrush—65 percent sagebrush, with the remaining cover scattered cheatgrass and annual weeds; (2) cheatgrass plus sagebrush—55 percent cheatgrass forming a complete cover beneath the sagebrush; and (3) cheatgrass plus other grasses—the cover being cheatgrass and bunchgrasses.

The basic data gathered included dry bulb temperature, relative humidity, dew point, windspeed, burning index, plant species, plant volume and continuity, and forward rate of spread in chains per hour on going fires. Weather measurements were taken on the fireline with a Forest Service Ranger Belt Weather Kit, and a portable, hand-held anemometer was used to obtain windspeed measurements. Rate of spread was measured either by pacing or measuring the distance by tracking the fire with a truck or four-wheel-drive vehicle.

The data were statistically analyzed on an IBM 709 machine. The program used is designated as the BIMD 06 multiple regression program. The data processing work was done by the Western Data Processing Center, Graduate School of Business Administration, University of California.

Output of this program includes the following, for all possible combinations of the variables that were used: (1) Sums, (2) sums of squares, (3) means, (4) standard deviations, (5) cross product sums, (6) cross products of deviations, (7) correlation coefficients, (8) analysis of variance for the multiple regression, and (9) computed F values.

Variables used in this analysis were relative humidity, dew point, burning index, average windspeed, and dry bulb temperature. The variables of fuel type, topography, and fuel type continuity were separated from the other variables for sets of observations.

The study resulted in four regression equations from which four rate-of-spread tables were calculated for the following sets of observations: 1. Fuel type, sagebrush; continuity, uniform; topography, flat to rolling. 2. Fuel type, sagebrush; continuity, patchy; topography, rough to steep. 3. Fuel type, cheatgrass plus sagebrush; continuity, uniform; topography, flat to rolling. 4. Fuel type, cheatgrass plus other grasses; continuity, uniform; topography, flat to rolling.

The final equations do not necessarily represent the ultimate combination of variables, but they do represent the best answers obtainable for the range of data involved.

# LIQUID NITROGEN AND SOLID CARBON DIOXIDE AS FOREST FIRE SUPPRESSANTS

ARTHUR R. PIRSKO, *Forester*, and LEO V. STECK, *Consultant in Chemistry, Pacific Southwest Forest and Range Experiment Station*

Fire retardants in current use are effective only on the cooler flanks of fires.[1] Because of this, firefighters have long hoped for a suppressant that will stop the rolling front of a fire in trees or brush. Exploratory tests were made in 1960 of two materials that seemed to offer promise: liquid nitrogen and solid carbon dioxide. Because these two gases are extremely cold (solid carbon dioxide, —78° F.; liquid nitrogen, —195°), it was thought that they might help cool a fire. Storage and handling problems created by their coldness appeared capable of solution by techniques designed by industrial and military users.[2]

## TEST PROCEDURE

Liquid nitrogen was poured on test fires from small Dewar flasks or dropped in a polyethylene bag that shattered on impact. It was also allowed to flow down a 10-foot galvanized iron trough, in order to simulate liquid and gaseous nitrogen approaching a forest fire down a hillside.

Solid carbon dioxide was supplied as a 50-pound bag of pulverized material. Much of it had coalesced during storage, and although it could easily be broken up by stirring vigorously with a metal rod, some remained as lumps ¼ to 1 inch in diameter. It was shaken out from a container held above the fires.

For the laboratory experiments, fire test cribs were built according to a pattern described by Fons, et al.[3] The cribs were 6 inches high, 8 inches wide, and 17 inches long, and they were made of ½-inch ponderosa pine dowels on 1¾-inch centers. The dowels were bonded at each junction with resorcinal-formaldehyde resin glue. Cribs averaged approximately 1,350 grams in weight. Their moisture content was not determined, and they were used without ovendrying. These cribs were placed on a 6- by 6-foot iron pan and ignited with burning hexane at several places in the bottom layer of dowels.

A directional radiometer was wired to a recording potentiometer to measure relative radiation from the fire. When radia-

---

[1]Miller, H.R. Chemical fire retardants for wild land fire control. U.S. Forest Serv. Forest and Range Expt. Sta. Res. Note 105, 5 pp. 1959.

[2]Anonymous. Pressure's on in cyrogenics. Chem. and Eng. Newsletter 37 (13) : 50–51. Mar. 30, 1959.

——— Cyrogeneering. Indus. Bul. 375. Arthur D. Little, Inc. Cambridge, Mass. May 1960.

[3]Fons, W. L., H. D. Bruce, W. Y. Pong, S. S. Richards. Project fire model. U. S. Forest Serv. Pacific Southwest Forest and Range Expt. Sta. Summary Prog. Rpt., 56 pp., illus. 1960.

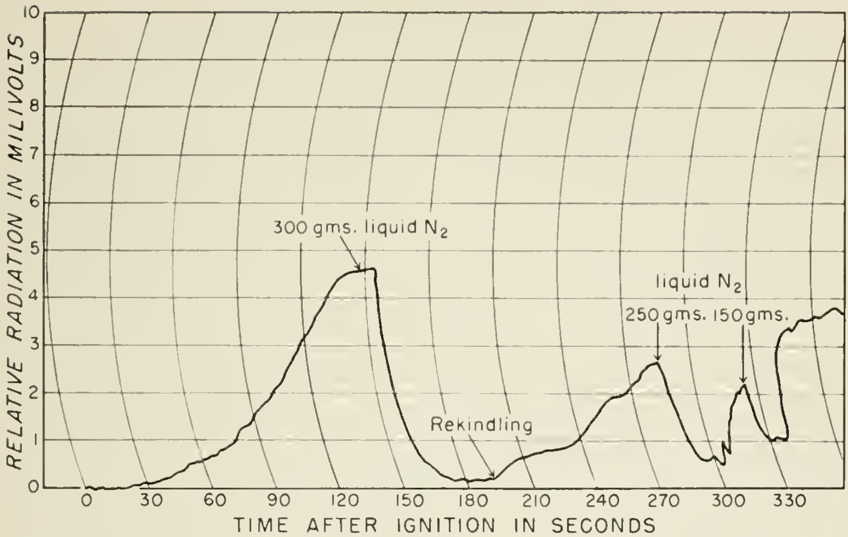



FIGURE 1.—Radiometer trace for application of liquid nitrogen on test fire.

tion was judged from the potentiometer trace to be at a peak, the suppressants were applied to the fire (fig. 1).

For tests outside the laboratory, a large crib was made of acacia bolts 6 inches in diameter and 24 inches long that were split lengthwise. Six bolts were stacked three tiers high with excelsior and small pieces of wood for kindling. At maximum intensity of the acacia fires, liquid nitrogen or solid carbon dioxide was poured directly on the fires from a polyethylene beaker.

## EXPERIMENTAL RESULTS

### LIQUID NITROGEN

When 300 grams of liquid nitrogen was poured down a metal trough that was 3½ feet from the burning crib in the laboratory, the flames went completely out, but the fire rekindled in a very short time. Fire charring of the dowels became deeper as time passed, and additional applications of 300 grams of nitrogen had no appreciable effect. A similar result occurred with trough application of 750 grams of nitrogen on another crib and with direct application from a flask—the flames were temporarily extinguished until rekindled from deep charring.

With the crib fire of acacia bolts outside the laboratory, results were even less encouraging. Although nearly all the flames were knocked down temporarily, they flared up again within a few seconds.

### SOLID CARBON DIOXIDE

About 250 grams of pulverized carbon dioxide was shaken from a container over the laboratory fire. When solid carbon

dioxide surrounded the dowels, the flame was extinguished. Other parts of the crib continued burning. An additional 1,000 grams of carbon dioxide extinguished all flame but left glowing embers at one end of the crib. These embers did not rekindle the fire, but they continued to glow until more carbon dioxide was applied.

On the outside fire, 2,000 grams of carbon dioxide was shaken from a container. Only where the chemical hit the logs was the fire extinguished. Wood not in contact with the carbon dioxide continued to burn. A 20 m.p.h. wind dispersed any carbon dioxide gas from the immediate fire area.

## CONCLUSIONS

Even though applied to crib fires at the rate of 1 to 2 pounds per square foot of burning area, liquid nitrogen apparently did not absorb enough heat to reduce the temperature of all the burning wood below the ignition point, and the gaseous nitrogen did not reduce the oxygen content of the air below that necessary to support combustion.

Carbon dioxide was better than liquid nitrogen in extinguishing the small crib fire in the still air of the laboratory, but it was poorer than liquid nitrogen when applied to the larger outside crib. It was not possible to extinguish all the flames in the outside crib even with an amount of material far in excess of what could be considered practical for field use.

Handling liquid nitrogen for these tests was about as difficult as handling hot water. Comparable safety precautions were used to avoid spilling on skin or holding uninsulated containers with bare hands. Solid carbon dioxide was more difficult to apply than liquid nitrogen.

On the basis of these tests, further study of liquid nitrogen and solid carbon dioxide as fire suppressants does not seem warranted.

# LIGHTWEIGHT LOADING RAMPS FOR TRACTOR-TRANSPORTS

HUGH MOBLEY
*District Ranger, Kisatchie National Forest*

When beds were built for new tractor-transports on the Catahoula Ranger District, a new lightweight loading ramp was designed and constructed. The old ramps constructed of steel were heavy and cumbersome and required two men to handle. On some transports wooden ramps were used but these were also cumbersome and heavy and continually required repairs.

The ramps had to be strong enough and wide enough to accommodate a crawler-type tractor (approximate weight 5,000 pounds), and the narrow-gage wheels of the plow. In addition, each ramp should be light enough for safe handling by one man (figs. 1 and 2).

The ramps are constructed of three 3-inch aluminum alloy channels (7 feet long) with angle-iron cleats ($1\frac{1}{4}$ by $1\frac{1}{4}$ inches and 18 inches long) spaced $7\frac{3}{4}$ inches apart. Angle-iron rather than aluminum cleats are used because aluminum is too soft to withstand the wear of the tractor tracks. The angle-iron cleats are welded to flat steel straps ($\frac{1}{8}$ by $1\frac{1}{2}$ inches) which are bolted to the top flange of the 3-inch aluminum alloy channels (fig. 3).

The steel straps are welded to a steel plate or strap across the top end of the ramp to keep the tracks from breaking them loose. These steel straps save wear from the tractor tracks to the aluminum alloy channel. A hole is cut in the angle iron at the bolt location, which leaves the bolt head recessed (fig. 3). Another

FIGURE 1.—Lightweight aluminum loading ramp easily handled by one man.

method is to bolt the strap to the aluminum channel first and then weld the angle-iron cleats on over the bolt heads. Either way the bolt heads are protected by the angle-iron cleats and are not subject to being sheared off by the tractor tracks. To provide added rigidity to the ramp, two 5/16-inch bolts inside pipe spacers are used between the three channels.

To hold the ramp to the truck while loading and unloading the tractor, a steel plate (¼ by 3 inches) is bolted to one end of the aluminum channels. This plate fits over two lugs on the truck bed (above license plates in fig. 1) and holds the ramp in place. One end of each steel strap is welded to this plate.

The ramps, 7 feet long by 18 inches wide, can be carried on the bed of the truck outside the plow and held in place by spring clamps. When carried in this position they are not as subject to mud and dirt from the rear wheels as they would be if carried under the bed.

The weight of one aluminum alloy ramp is about 65 pounds compared to approximately 119 pounds for similar ramps with steel channels. One man can safely handle the aluminum ramps. It required two men to handle the steel ramps.

The cost of materials and labor for one aluminum alloy ramp was $94; the estimated cost of a steel ramp was $81. It is felt that the $13 difference in cost is more than made up by the ease, safety, and convenience in handling. Ramps for tractors heavier than those shown here can be constructed by using either larger aluminum alloy channels or I-beams.

These aluminum alloy ramps have been in use for one fire season and have proved very satisfactory and serviceable. One set of ramps has been used an estimated thirty times for loading and unloading with no appreciable signs of wear.

FIGURE 2.—Unloading tractor by means of two aluminum alloy ramps.

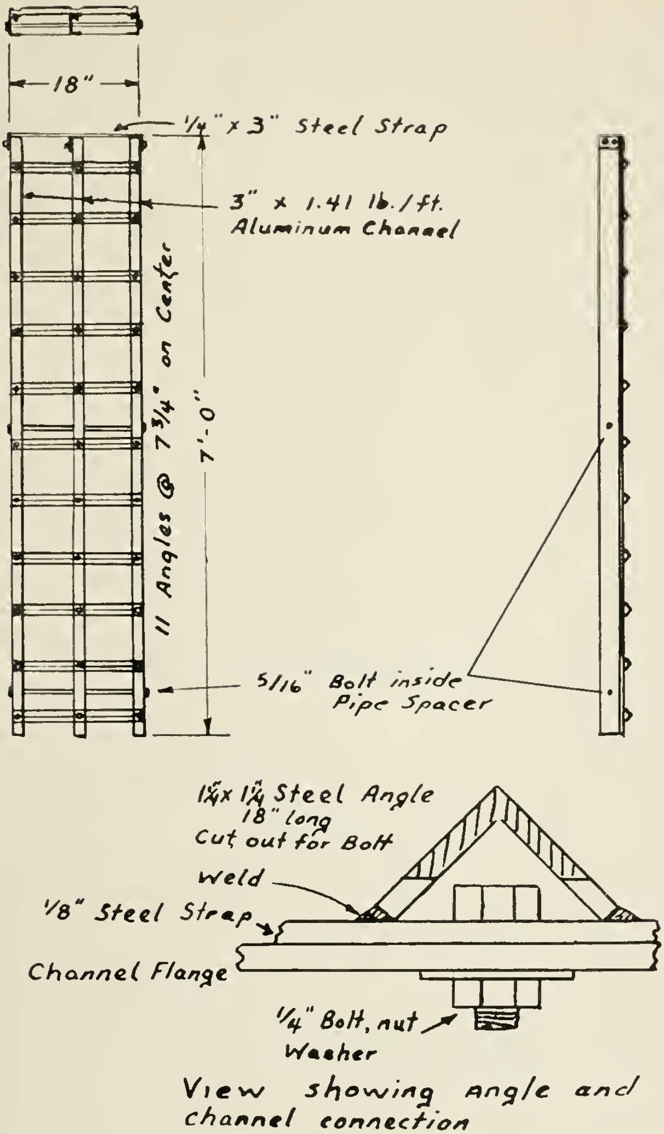



FIGURE 3.—Construction details of aluminum loading ramp.

# INDEX, 1961

[Jan., pp. 1-26; Apr., pp. 27-72; July, pp. 73-102; Oct., pp. 103-130.]

## INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. ***Paper clips should never be used.***

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.


A growing
America
needs growing
forests...
don't let them
go up in smoke!
SMOKEY
prevent forest fires!

VOL. 22 JULY 1961 No. 3



# FIRE CONTROL NOTES





A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

UNITED STATES DEPARTMENT OF AGRICULTURE 1862 1962

Growth Through Agricultural Progress

Volume 22 Number 3

# FIRE CONTROL NOTES

## A Quarterly Periodical Devoted to the

## TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (October 17, 1958).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1961

# CONTENTS

# TACTICAL USE OF FIRE RETARDANTS FROM THE AIR

William E. Murray
*Assistant Forest Supervisor, Toiyabe National Forest*

The roar of powerful aircraft engines and the cascading of a thousand gallons of fire retardant marked another tactical application of fire retardants by aerial methods. This was part of the air tanker program of the Intermountain Region, U. S. Forest Service. Following successful field tests in California, the first air tanker unit in the Intermountain area was established in 1957 on the Boise National Forest. Since then the program has expanded to include 7 of 18 national forests in the region. Nearly 400,000 gallons of fire retardants were used in 1960.

The end of the expansion is not in sight. Proper use of retardants is the end point of successful programming. Although much has been learned, it is imperative that we continue to record, analyze, and report on this important fire suppression tool.

## ACCEPTED TACTICS

Tactics in fire suppression can be defined as fire control action based on what needs to be done, where, how, and when. The definition of tactics for the aerial use of retardants is no different; all the factors that influence fire behavior, fire control, and safety must be weighed carefully. Tactical use now accepted generally in the Intermountain area is as follows:

*Small fires.*—Air tankers are perhaps most valuable for initial attack, knocking down and corralling small, dangerous fires. Although a few fires may be extinguished by this method, ground action is almost always required to complete the job. The key to successful initial action on small fires is fast attack. Decisions on air tanker use are based on fire behavior, expected effectiveness of the drop, resource values, elapsed time for ground crews and the air tankers, and comparative costs with and without the use of air tankers.

Air tankers also can be used effectively for followup on small troublesome fires that threaten to escape control of ground crews.

*Large fires.*—Tactical use of air tankers on large fires embodies the same principles used in ground attack. In general, however, air tanker attack should be limited to situations where the chance for successful action is high and benefits will more than offset costs. Sound, experienced judgment is needed during the entire operation.

The most effective result expected of air tanker action on large fires generally is the stopping or delay of fire spread. A hotspot attack, spot-fire attack, or temporary control line may be involved.

Attack on the head of the fire normally should be considered first. However, unless the head of the fire is small, fuels are light, or sufficient air tankers are available to achieve the objective, flanking attack usually will be more effective. Often these decisions must be made when the air tanker is already over the fire, in many cases by the initial attack pilot. Preferably, they are made by the air attack boss under the direction of the line boss.

Frontal attack can be effective on a ridgetop or along a change in fuel type where there is a better than normal chance to stop fire spread. Frontal attack may also be sound where delaying tactics can prevent fire from running into areas where it will be more difficult and costly to control.

Flanking attack on badly spotted areas or on small fingers to keep fires from fast-spreading, heavy fuel areas or steep topography will likely do more to lessen the total perimeter than attack on the main head of the fire.

Besides its value for initial attack, the use of retardant for hotspotting has proved most successful. Flareups can be knocked down effectively to keep fire within planned limits. This applies to spot fires outside the line as well as to crown or ground fire runs within the planned or constructed line. Spot fires can often be prevented by timely action on brand-throwing snags and flareups.

Air tankers are also used on large fires to lay continuous preplanned control lines of retardant, either alone or coordinated with ground forces. Retardant firelines are placed in locations similar to those constructed by hand or machine, and with the same attack objectives: (a) direct attack by laying the line on the fire edge; (b) parallel attack by laying the line a short distance from the fire edge, primarily in coordination with ground crews to shorten lines on irregular fire edges; and (c) indirect attack by laying lines fairly distant from the head or flanks from which ground crews can backfire or burn out. Because of safety factors, direct-attack retardant lines generally are laid as extensions of lines constructed by the ground crew rather than concurrently with the ground crew.

When air tankers and ground crews are conducting a coordinated direct attack on the same sector, the air tanker is best used as an advance hotspotting unit to knock down and cool the fire. This enables ground crews to work safely on the fire edge. Air tankers are also useful as control support during the burning-out phases of parallel and indirect attack. Complete coordination is necessary, however, to be sure retardants are dropped only on dangerous hotspots and not on the planned burning.

Air tankers can be effective in strengthening control lines, particularly in sectors with hastily constructed shoestring lines. They can also be effective in the fireproofing of larger areas outside the lines where the potential of spotting is great.

Retardant line-laying around improvements, pretreatment of improvements, and suppression of blazes already started are acceptable uses of the air tanker if benefits justify the costs. Similar tactics can be used to protect personnel and equipment.

## BASIC REQUIREMENTS

*Initial planning.*—Use of air tankers is a costly operation, including the establishment of the program and actual employment of personnel. Consequently, various decisions must be made before tankers are obtained. Will tankers produce more effective control than other methods? Are suitable operation bases available? Can qualified pilots and ground personnel, satisfactory aircraft, and adequate communication be obtained?

*Basic plans and needs.*—Operation bases should be strategically located for maximum mobility and minimum flight time. The primary base should be as near the center of expected activity as possible. Mixing and loading facilities must be adequate to handle normal planned use and also adequate for expansion to meet maximum sustained operation. Supplemental portable equipment may provide the overload facilities needed at the primary base as well as the temporary facilities needed at secondary bases. Water supply, tank storage, electricity, communication, and aircraft servicing facilities are all essentials at the primary base.

Concurrent with selection of base facilities is determination of the retardant(s). Effectiveness as measured by density of material, tested dispersal patterns, penetration, and lasting retarding action should be considered. Cost comparisons should be made, including basic materials, transportation, storage, mixing equipment, and mixing crews. Possibilities for adequate backup supply support during sustained operations should be explored.

Firm arrangements for adequate numbers of suitable aircraft should be made. Number, type, and capability should be determined, based upon distance involved, speed, maneuverability, capacity, drop characteristics, landing field requirements, and rental rates. Satisfactory tanks and gates are essential. Suitable lead planes and other control aircraft should be included and helicopter tankers considered.

Reliable radio communications are an absolute necessity for safe and effective operations. Air-to-ground communications with the base, dispatching headquarters, and ground attack forces are as essential as air-to-air needs.

Manpower requirements must be met fully and all segments well organized. Skilled and experienced pilots must be obtained along with adequately trained men to handle base operations. The lead plane pilot and at least one tanker pilot should be qualified as an initial attack pilot. Pilots' qualifications and training should be verified through preseason checks. Provision must be made for relief pilots and ground crews during sustained operations. All manpower assigned should be welded into a smooth functioning team that can be integrated into a fire suppression organization of any size. The air attack organization for large fires must be developed so that control is maintained over each part of the entire air operations at all times. Fully trained and qualified individuals should be available to fill air officer and air attack boss positions.

Training in air tanker operations is a "must job" that should extend to all levels in the fire organization. Base personnel must

have training in all phases of base operations and in large-fire organization. As a minimum, pilots should receive training in fire organization, fire behavior, tactics, drop techniques, and safety. They should be given written guides and rules for safe and effective operations and should receive in-flight drop training. Fire overhead who may utilize air tankers should be trained in aerial tactics, organization, and traffic control, with in-flight or mockup training provided for those who will fill specific positions in the air operation organization. All other fire personnel must receive training in the safety aspects of aerial operations.

A system of recordkeeping and reporting is vital to the air tanker operation not only for financial control but also for evaluation of results. Procedures should be well established prior to the start of seasonal operations.

A safety plan should be prepared for each base and adequate aerial safety rules and instructions incorporated in other plans and training programs.

*Operating plans.*—The success or failure of any tactical mission depends to a large degree upon the adequacy of mobilization and dispatching, as may the efficiency, effectiveness, and safety of the entire air tanker operation. Preseason planning and preparedness plus a highly competent dispatcher are required.

Preparedness for the dispatcher must include well-conceived action guides that remove much of the guesswork. As a minimum, an air operations map should be prepared which will show aerial tanker use areas and flight hazard areas. It should be based upon flight time, travel time for ground crews, resource values, fuel types, and topography. From this map, dispatching guides can be developed for various fire danger classes. Type and strength of initial attack and the followup required should be included in the action guides as well as provision for aircraft and ground crew standby and automatic dispatch.

The action plan should provide for guide modification by the dispatcher as needs dictate and include a list of operational limitations that may be encountered by the various aircraft. Since this modification will be based upon availability of ground crews, fire behavior, rate of speed, wind and other weather and flight conditions, provision should be included for the collection of this information. Pilot briefing should be incorporated in the action plan so that all pilots are completely apprised of the mission to be accomplished, responsibility for drop decision, traffic control over the fire, and flight hazards. Maintenance of control at central headquarters over all aerial operations should be spelled out.

## CONCLUSION

The use of fire retardants from the air has proved to be a fire control tool of great potential. Not all use has been effective nor have all operations been efficient and safe. Yet, considerable savings have been made through the use of this tool and serious accidents held at a low level. A continued expansion of the program, however, will depend upon more effective, efficient, and safe operations. A better understanding and use of acceptable tactics preceded by more careful planning and direction is needed.

# NIGHT ATTACKS WITH TRACTOR-PLOWS IN THE SOUTH

R. J. RIEBOLD
*Forest Supervisor, Florida National Forests*

The odds are in our favor when we make night attacks with tractor-plow teams on fires in the southern Coastal Plain. Although such attacks have some handicaps, there is a big advantage in reduced rate of spread during the night hours. The differences in fire behavior reported here, and in the burning conditions that caused them, were observed at a night attack training session on the Ocala National Forest January 31, 1961.

Two training fires were held on a 10-chain fire training strip in a 6-year rough of wire grass and palmetto under mature longleaf pine.[1] One fire was at 3:00 p.m. The other was at 10:00 p.m. and adjacent to the first one. Fuel moisture and wind velocity measurements were made at the fire danger station about 6 miles from the training strip. These were taken hourly from 8:00 a.m. January 31 to 8:00 a.m. February 1. On January 29, two days before the training fires, 1.83 inches of rain fell at the fire danger station.

During each fire, the rate of forward spread was measured by placing steel-can markers at the flame front at 1-minute intervals. Head fires were used both times. The attacks on the two fires were by a tractor-plow team led by a district ranger, and they were observed by fire men of greater experience who later participated in discussions. The differences in fire behavior and weather conditions were as follows:

| | *Day fire* (3:00 p.m.) | *Night fire* (10:00 p.m.) |
|---|---|---|
| Fuel moisture, percent | 6 | 16 |
| Wind velocity, m.p.h. | 4 | 0 |
| Burning index (8-100-0) | 5 | 0 |
| Average RFS, chains per hour | 33 | 3 |
| Average flame height, feet | 25-30 | 5-10 |
| Backfire distance, chains[1] | 5 | 1½ |
| Parallel backfire distance, chains | 1 | ½ |
| Meeting distance, head fire and backfire from plow line, chains | 1½ | ½ |

[1]On the day fire, the ranger's 1-minute observation of rate of forward spread was 50 chains per hour. Observers agreed that the backfire distance taken was about right.

The fuel moisture readings are shown in figure 1, wind velocities in figure 2, and burning index in figure 3. Although it is not customary to keep weather records throughout the night, the fire dispatcher and others who are familiar with weather conditions in the locality said that, except for the rise in wind velocity around 7 o'clock, the pattern was typical of the winter fire season.

[1]The use of fire training strips was described by the writer in Fire Control Notes 20(3): 69-76, illus. 1959.

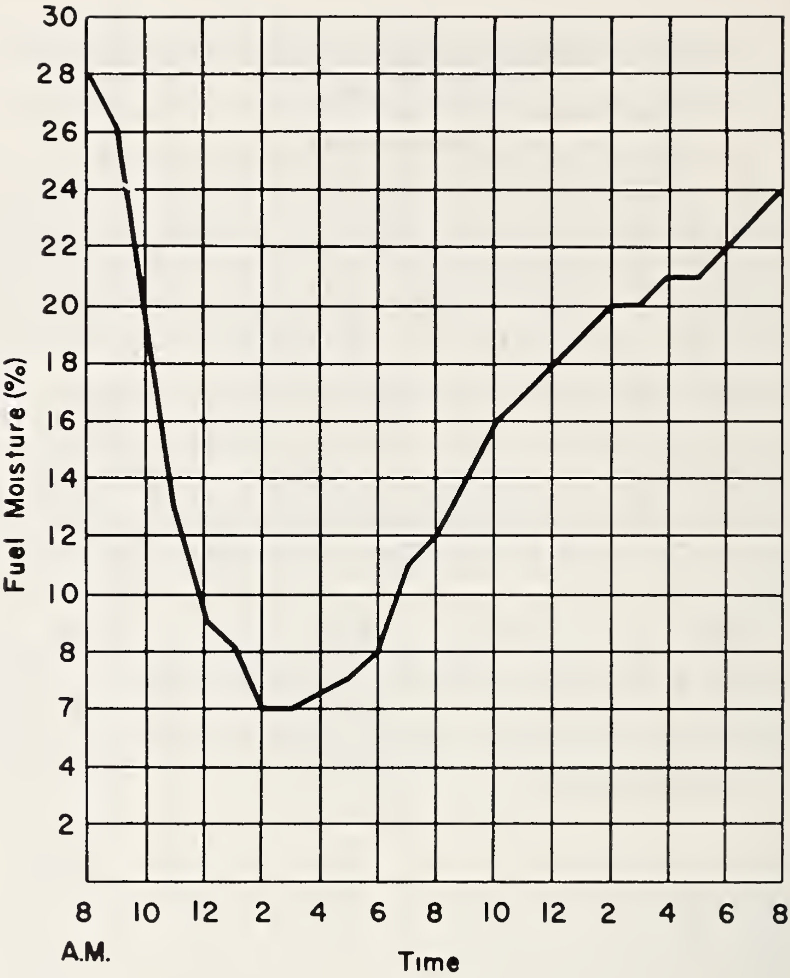



FIGURE 1.—Fuel moisture for 24-hour period.

It is evident that conditions most favorable to an attack occur between 8:00 p.m. and 8:00 a.m. Wind velocity is low and fuel moisture is rising. The combination results in milder fire behavior. This is the principal advantage in night attacks. It should be remembered that the night attacks discussed herein are initial attacks made with tractor-plow teams on fires that started at night or late in the afternoon.

The day after the training fires, about 30 fire control men, some with many years of experience, discussed the problem of night attacks with tractor-plows. It was agreed that night attacks are to be used as fully as possible in spite of some of the handicaps and problems involved. It was evident that the problems are created principally by darkness and by fatigue and sleepiness that

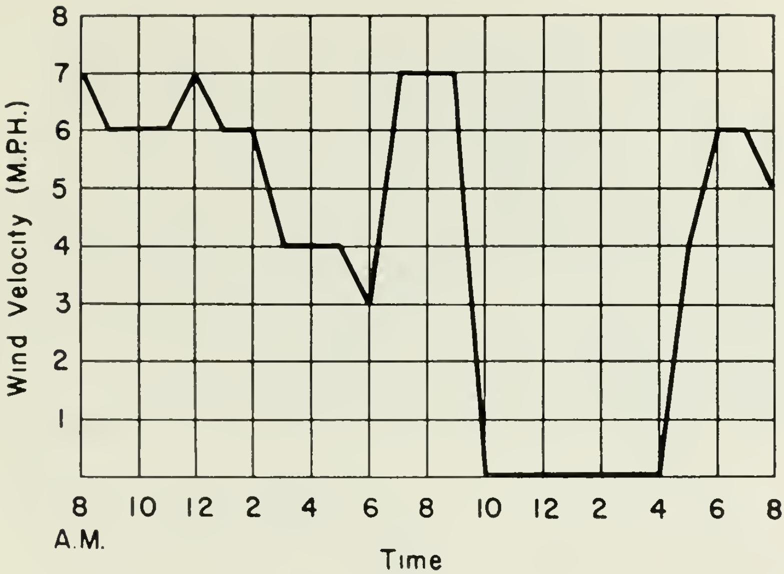



FIGURE 2.—Wind velocity for 24-hour period.

accompany night work, especially if men have worked or traveled during the preceding day.

Darkness prevents air scouting; observers can see fires but cannot locate landmarks. Darkness also hinders ground scouting and even the use of aerial photos; it is very difficult to locate bays and swamps in flat country at night by either method. Deciding what is ahead of the fire and what is ahead of the plow is more difficult at night. It is also more difficult to ascertain the width of the head of the fire if it is beyond immediate vision.

Darkness also brings increased danger of accidents with trucks, especially if there is smoke, and with tractors. In fact, experienced tractor-plow operators were unanimous and firm in saying that having a lead man was too dangerous; they could not watch for his safety and they did not need him to avoid holes or stumps. It was also recognized that there are greater possibilities of injury from falls and handtools, and that eye injuries from twigs are more likely at night.

The following suggestions were made as to means of relieving the handicap of darkness. Scouting can be done well enough if local men are used as guides rather than on other jobs. Dispatchers can help read aerial photos and direct crews if lookouts can give accurate fire locations and crew locations can be pinpointed. Less hazardous working conditions at night can be brought about by good foremanship; good crew organization and discipline are essential. The foreman should remind men of safe practices to avoid night hazards. Good lights, preferably head lights, are desirable but not every man need have a light. Tractor-plows are equipped with lights, front and back. Even though tractor operators do not want a lead man, they wish to have another man

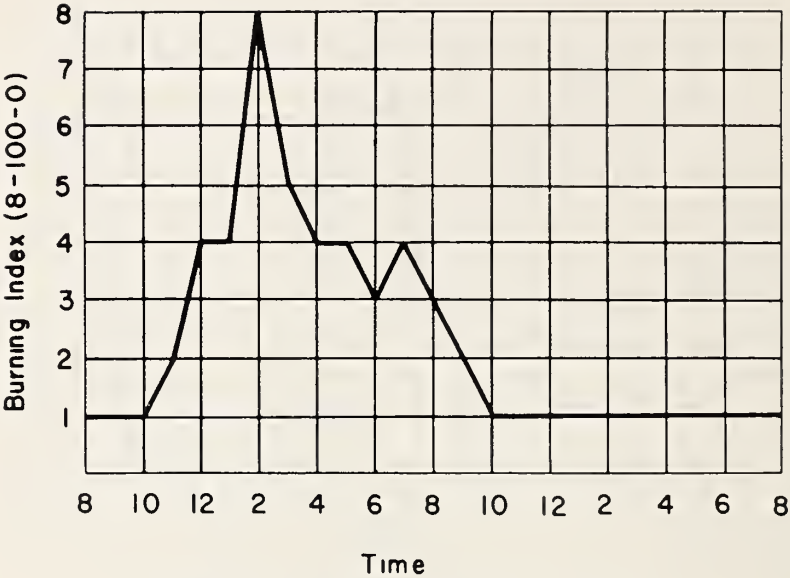



FIGURE 3.—Burning index for 24-hour period.

handy, preferably one who can operate in an emergency and who can assist if the tractor lodges on a stump. Line firing and holding are faster at night, but tractor-plows can still keep ahead of crews while operating at lower speeds. Slower truck driving, especially if there is smoke, was emphasized as an important safety measure.

To help overcome the handicap of fatigue and sleepiness associated with night work, it was agreed that 12 hours of tractor-plow operation should be the limit. The most practical suggestion was to arrange two split shifts of 6 hours each during the night. This would enable each operator to get some rest. The crew members could also be shifted, but doing so was considered not especially important because of the easier work at night. The men should be fed, of course, during the night. The tractors are tireless but, as one man said, "they do get hot, dry, and thirsty." With the declining burning index in the early evening, it was considered desirable to service the tractor-plows before dark. Operators said they could do so faster and better, particularly where visual checking is involved. In general, if a night shift is needed, the need should be realized before 5 o'clock so that arrangements can be made with the districts from which reenforcements or replacements are to be obtained.

The conclusion was that even though tractor-plow teams might have difficulties with severe fires all afternoon, they could look forward with confidence and relief to the 12 hours from 8 p.m. to 8 a.m. during which they could easily close lines, fire them, and mopup.

# IRRIGATION PIPE ON FOREST FIRES

STEVE SUCH, SUPERVISOR,
*Forest Fire Experiment Station, Michigan Department of Conservation*

Effective forest fire suppression requires a large variety of materials, equipment, and techniques. Among the many useful and practical types of equipment making an appearance on the fire scene is aluminum irrigation pipe.

Irrigation pipe first came into fire control use in Michigan in the early 50's and has become increasingly more popular. The many advantages of irrigation pipe over hose, and some of its applications, are well covered by L. A. Dorman.[1] In his article Mr. Dorman summarizes the distinct advantages of irrigation pipe as follows:

1. Faster to lay and to pick up.
2. Less labor to handle.
3. Cleaner and easier to handle.
4. Less maintenance, especially in cleaning, drying, and storing.
5. Usable over greater distances because of low frictional losses.
6. No deterioration in storage.
7. Greater lifetime than hose.
8. General all-round usefulness.

Since this article appeared, irrigation pipe has been used successfully on many fires in Michigan. Field personnel attest to its excellence with enthusiasm. Used mainly on fires requiring large volumes of water, irrigation pipe has been found ideal for muck and ground fires.

Transportation of this pipe is facilitated by the use of a special four-wheel tandem-axle trailer, designed to accommodate either 16-foot or 20-foot lengths of pipe (fig. 1). Any given trailer may carry one of the following quantities with the necessary fittings:

1. 100 lengths, each 3 inches by 20 feet.
2. 195 lengths, each 2 inches by 20 feet.
3. 50 lengths, each 3 inches by 20 feet, and 88 lengths, each 2 inches by 20 feet.

Aluminum pipe is especially light in weight and unusually strong. Pipe 2 inches in diameter, 20 feet long, weighs 9 pounds. Pipe 3 inches in diameter, 20 feet long, weighs 12 pounds. The 2-inch pipe has a bursting pressure of 300 p.s.i., and the 3-inch pipe a bursting pressure of 250 p.s.i. Sections are connected by steel ball couplings which are permanently affixed to the pipe.

[1] L. A. Dorman. Use of irrigation pipe in forest fire suppression. Fire Control Notes 15(3): 9-13, illus. 1954.

FIGURE 1.—A four-wheel tandem-axle trailer with a full load of aluminum irrigation pipe ready for dispatch to fire. Pipe can be handled fast and efficiently.

Coupling is accomplished by a push, and uncoupling by an easy twisting pull. A flexible steel coil spring makes both a positive lock and seal with the slightest water pressure.

Although in appearance, aluminum pipe looks rigid, it is surprisingly flexible at the joints, permitting up to 22 degree displacement for placement on rough terrain. This feature alone allows this pipe to be used on practically any forest fire, including those in dense growth of trees and on rough ground found in Michigan.

A 12-foot length of 2½-inch discharge hose is coupled between the pump and pipe to act as a damper. Each irrigation pipe trailer permits the use of up to eight or ten discharge lines, although in practice two or three are the most that are used.

The pump used in conjunction with irrigation pipe is generally of the centrifugal type, and is trailer mounted. Most of the units in Michigan are capable of displacing 500 g.p.m. at 120 p.s.i. They are powered by a 115 hp. industrial engine. The centrifugal pump costs approximately $2,600 and total cost of the trailer, pipe, and fittings, is approximately $2,100.

The many satisfactory experiences with irrigation pipe make certain that its use in Michigan will remain one of the standard methods of pumping water on forest fires. The amount used will surely increase. Further information may be obtained from the Michigan Forest Fire Experiment Station, Roscommon, Mich.

# BOMBARDIERS FOR MARSH FIRE CONTROL

Don Wilson
*Fire Chief, Minnesota Division of Forestry, St. Paul, Minn.*

The Minnesota Division of Forestry put one specially equipped Bombardier crawler vehicle in service on swamp grass fires in the spring of 1960. An iron-mesh cab was installed to protect the driver and crew from brush, falling limbs, and timber. Two 150-gallon, low water tanks were installed directly over the tracks for better weight distribution. A pump powered by a 3 hp. air-cooled motor was mounted on the rear deck. It is capable of pumping 7 g.p.m. at 100 pounds pressure through 150 feet of 1-inch rubber hose on a live hose reel. Racks in the cab carry six backpack pumps, four No. 2 shovels, and four 3½-pound axes (fig. 1).

The Bombardier was used on 11 fires and controlled 840 chains of lowland fireline in 30 hours of operating time. Only on one fire was a refill of water tanks necessary. A water extender was used on all fires. Much of the 840 chains of fireline was controlled by actually driving on the fire and smothering it with the tracks, or by establishing a wet control line in front of the fire. The moisture in the peat was brought to the surface and thrown by the track


Figure 1.—The Canadian-manufactured Bombardier operates on endless rubber and rayon belts, and with lugs running over pneumatic tires that have less than 1 pound of ground pressure per square inch. The two 5½-foot long tracks, each 29 inches wide, carry the (11′8″ by 7′3″) vehicle powered by a 115 hp. 6-cylinder motor. Maximum road speed, 25 m.p.h.

action at the same time that the fuel was tramped down; this created a firebreak that was in most instances effective.

Fire throwovers were taken care of by firefighters on foot in the followup action or by turning back with the Bombardier to control the spots. When the fast rate of spread and the presence of smoke necessitated the use of water through the pumper, there was a definite advantage in operating on the burned side of the fireline. Operating in this position allowed the Bombardier and the crew to work much closer to the actual fire, and it proved much safer and more effective. Also, the driver was able to see any stumps, rocks, logs, or even pools of water which would indicate softer and unsafe ground.

The most effective crew was composed of a driver, a nozzle man, and two or three men with backpack pumps to do the mopup. It is essential that the driver be acquainted with the vehicle operation and that the nozzle man be experienced in order to extinguish a maximum amount of fire without wasting water.

The vehicle can be operated over the road to and from fires under its own power. However, faster and safer travel with no track wear was possible by transporting it on a tilt-bed trailer behind a 2-ton truck.

Each piece of equipment tried for fire control by our Division is viewed with the thought of possible usefulness in other phases of our work. The Bombardier has already proved valuable in forest management. During the winter of 1959-60 it was used extensively in the remeasurement of many of the 1,200 continuous forest inventory plots.

A special heated cab was installed. It was designed to carry four men plus snowshoes and gear. Trips up to 8 miles one way were made. The use of the Bombardier resulted in the saving of much time and was an important factor in the early completion of the project. In addition, the vehicle was used in the cruising of Christmas trees in spruce swamps. Many of these swamps are intermingled with large open lowland grass areas, and the use of the Bombardier greatly simplified movement of the crew from one stand to another.

The Division has successfully developed a swamp tree planter to be used in State-owned nonforest swamp areas. Experimentation to date has indicated the effectiveness of the Bombardier to pull the swamp planter, and it is expected that this vehicle will play an important part in the program.

Obtaining sphagnum moss for use in packing trees produced in Division nurseries is an annual project that has presented transportation problems because of the very wet swamps. By using a special type of dray on which to load the wet moss, and the Bombardier for pulling, a former problem became a routine job.

To date the one Bombardier owned by the Division has been used a total of 1,000 hours. Operating costs have totaled $247 and maintenance costs $1,100, which included one complete set of tracks. It is expected that a major motor overhaul will be necessary at about 2,000 hours and that maintenance costs after 3,000 hours will make retention of the vehicle prohibitive.

A smaller model of the Bombardier is also manufactured, and we plan to acquire one for trial. It is 2 feet 4 inches shorter, with 20-inch wide tracks but with the same motor power. It is capable of carrying two men for timber management work and probably half the amount of water and firefighting equipment. We believe that this unit will be nearly as effective for fire control work as the larger one, and it will cost much less. It should operate effectively on marsh fires with greater ease, and also provide faster transportation to fires since it can either be hauled on a truck bed or on a smaller trailer drawn by a pickup truck.

The Bombardier, when obtained in quantities that we need, will be a most effective fire control tool in our problem areas, and at other times it will provide us with a more effective means of carrying out other phases of our work.

☆ ☆ ☆

## Here's Proof: Cigarettes Do Start Forest Fires

This cigarette-caused fire could have become a large fire, but fortunately it was found while still a "smoke."

Even though the dry grass and needles on the ground were sparse, the cigarette had started a smoldering fire that could have spread rapidly with the right conditions.

Some skeptics say that cigarettes will not cause forest fires. This photo is evidence that they will.—Danny On, *Assistant Ranger, Kootenai National Forest.*

# WATER USE FROM LIGHT AND HEAVY TANKER-TRUCKS

JIM JAY, *Fire Staff Assistant, Lower Michigan National Forests,* and STEVE SUCH, *Supervisor, Forest Fire Experiment Station, Michigan Department of Conservation*

In Michigan, most forest fires are attacked initially by four-wheel-drive tanker-trucks. These units are capable of reaching practically all fires occurring in the State with the exception of fires along canoe routes or in swampy fuels. The very nature of the large areas of flashy fuels such as conifer slash and young conifer timber makes fast, mobile units essential. Years of experience have proved this type of equipment to be very practical and efficient for quick, decisive action in the early stages of fire in the woods.

The U.S. Forest Service and the State of Michigan both employ the four-wheel-drive truck as a water carrier because of its off-the-road performance characteristics. Michigan more often uses the heavier type truck, which carries as an accessory a hydraulically operated rear-mounted plow (fig. 1), whereas the U.S. Forest Service prefers the lighter units because of their greater flexibility for multiple purposes.

As a matter of practical tactics, tractor and plow combinations are used as an immediate followup to the tanker outfits, usually

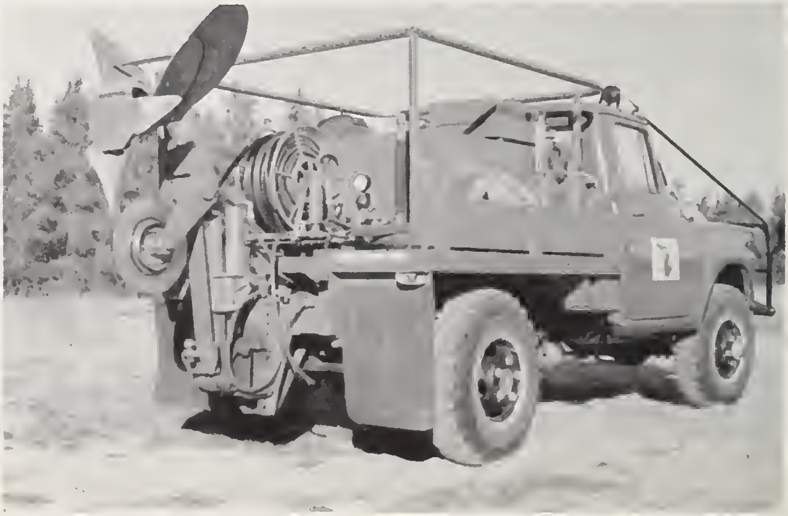


FIGURE 1.—Tanker-truck with mounted plow, Michigan Department of Conservation.

arriving on fires a few minutes after the pumpers begin their work. This "one-two punch" procedure insures effective, positive control of all but the most stubborn or explosive type of fires.

Although recent development of chemicals, retardants, and detergents as additives has greatly increased the efficiency of water, where the cost of these agents prohibit their use or their application is impractical, plain water is still superior to anything else yet known in producing a cooling and smothering effect in direct attack on forest fires. Consider the following from a recent report:

"The 300 gallons of water contained on the vehicle will provide 45 minutes of continuous fog, or as usually used on going fires, will provide intermittent operation up to several or more hours. The two 20-foot intake hose and injectors (tank refillers) permit filling of tank from any water source in less than 5 minutes. The high pressure fog discharge of the pump is instantly adjustable to any conical form from a wide bloom for close work to a driving, solid stream more than 30 feet long. High pressure fog puts out fire by cooling, smothering and blasting. The tiny water particles of the fog present a large surface area to the fire, and the heat of the burning fuel is almost instantly absorbed as these fine particles burst into steam, expanding the water to over 1,000 times its original cubic displacement. This steam replaces some of the air feeding the fire with resulting smothering or starving effect. Also, the tremendous velocity of the fog blasts the fire and tends to separate the flame from the fuel. The combination of the three aforementioned effects, plus the conventional dampening of the fuel, produces rapid extinguishment. A distinct advantage of high pressure fog is that it uses little water which is of vital importance in forest fire control. One gallon of water converted into high pressure fog will do the fire fighting work of many times that quantity at ordinary pressures."

Specifications for tankers may vary considerably, being generally dependent on the chassis rating of the basic vehicle. One-half-ton to two-ton trucks are commonly used. More accurately, these are identified by a gross vehicle weight rating such as 14,000 g.v.w. The g.v.w. determines the amount of payload that can be carried.

A broad specification outline and some major features embodied in state and federal tanker-trucks and their accessories is listed below:

*Truck*—any of many four-wheel-drive units up to 15,000 g.v.w., with transfer case and two-speed transmission permitting high and low range operation with 8 speeds forward and two in reverse. One specification for purchasing on a 11,000 g.v.w. truck calls for 130-inch wheelbase and 9.00 x 18 10-ply tires, as well as the transmission above.

*Water tank*—steel, hot galvanized dipped, capacity of 100 to 500 gallons, depending on truck size. Truck with 11,000 g.v.w. has 300-gallon tank.

*Pump*—any of several types and makes available, but positive displacement piston type is preferred for pressures up to 700 p.s.i and discharge to 20 g.p.m. Fog feature is important for best performance under certain conditions.

*Hose reel*—motor-driven re-wind live-reel type, usually with 200 feet of ½-inch high pressure (800 p.s.i.) hose.

*Discharge nozzle*—several commercial types available allowing straight stream to fog characteristics.

*Winch*—front mounted with cable to withstand maximum loads truck can exert.

*Radio*—two-way FM mobile units.

*Supplemental*—handtools, back pumps, emergency repair tools, first-aid kits, backfiring torches, tow chains, traction chains, water canteens, and emergency night lights.

*Optional*—attached hydraulically operated plows mounted on rear, used on trucks over 8700 g.v.w.

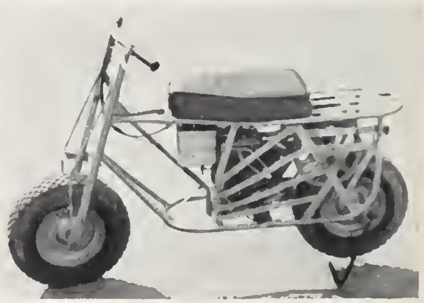
Tanker-trucks are conceded to have a top speed of 65 m.p.h. and may cost, depending on accessories, up to $8,500 fully equipped, including armor, which is standard on almost all units, to withstand rigorous use in rough and heavy cover.

Under actual fire conditions, water may be discharged from the tankers while the truck is in motion or when it is stopped. This implies considerable versatility in practical application. Refills are seldom required except on very large fires, but even then this requires only minutes, depending on the nearest source of water. For this purpose, large "mother" tankers are coming into more common usage. The mother tanker minimizes the "down" time on fire. They can be stationed in convenient locations along roads, trails, or in openings to best service the four-wheel-drive equipment in refills, and to provide a source of water for back pumps, water trailers, lighter tankers, etc. The use of mother tankers is similar to bringing the stream or the lake to the fire, especially if they are used in fleets.

☆ ☆ ☆

## Fire Prevention By Motor Scooter

Many national forests have recreation areas with heavy concentrations of human use. For each of these areas the workload can often require two or more fire prevention technicians. One immediate need is an efficient, economical means of transportation for the prevention technicians while they are working in these areas of high risk. To meet this need we tested a motor scooter in the Lake Arrowhead area, where there is an urban type concentration of fire risks, and in the Lytle Creek Canyon area, which receives heavy streamside recreation and residential use.



The scooter was easy to handle in congested areas such as campgrounds and lakeshore and streamside zones, offered excellent visibility and maneuverability for powerline inspections, and was readily adaptable to inspection and prevention patrol of foot and riding trails.—R. F. Johnson, *Fire Prevention Technician, San Bernardino National Forest.*

# THE OREGON STATE MOBILE FIRE WEATHER UNIT

CLIFFORD H. WATKINS
*Meteorologist, Oregon State Board of Forestry*

## Introduction

Firefighting strategy depends upon the weather. The placement of men with regard to their safety, the location of a fire trail, and the planning of a backfiring operation are examples of the kind of decisions which must be made by the fire boss. These decisions are based largely upon knowledge of current and expected weather conditions.

In order to provide the best possible weather advice for firefighting activities, the Oregon State Board of Forestry in cooperation with the U. S. Weather Bureau has developed a new mobile fire weather forecasting unit. The weather van is equipped to bring the very latest weather maps and weather teletype reports to the scene of a going forest fire. Hence, the fire weather forecaster, who operates with the fire behavior specialist as a member of the fire team, has at his disposal almost the same collection of weather data found at a major forecast center. These charts and reports are used to prepare the weather forecast.

The Oregon State Board of Forestry mobile unit is not a panacea for all the forecast problems that exist on fires, but rather it is a cure for a major ailment that has afflicted mobile unit forecasting in the past—that of inadequate weather analysis and reports. Undoubtedly occasional forecast errors will continue to occur, because of the limitations inherent in the science of weather forecasting. However, it is hoped that these errors will be reduced to a minimum by bringing the forecast office to the scene of going fires.

## Radio-Facsimile and Radio-Teletype

The U. S. Weather Bureau Analysis Center in Washington, D. C., prepares most of the weather charts used by forecasters in preparing the daily forecast. Pictures of these charts are transmitted by a facsimile machine (similar to wirephoto) over telephone cables from Washington to the various forecast offices. The U.S. Navy at San Francisco and other places receives these weather pictures and retransmits them on several radio frequencies to ships at sea for use by shipboard weather forecasters. There, they are received by a radio-facsimile recorder which is essentially the same type of machine used at land stations except that a special converter is used to convert the radio signal to a facsimile impulse. In addition to map pictures, the Navy broad-

casts weather teletype reports consisting mainly of weather observations and balloon measurements of upper wind and temperature conditions from various airport stations. These reports are received by a radio-teletype.

The Oregon State Board of Forestry Mobile Unit is equipped with radio-facsimile (fig. 1) and radio-teletype for intercepting the Naval broadcasts. The communication gear operates on a new converter principle developed by the Department's Radio Engineering Section and requires only a standard shortwave receiver, whip antenna, and 110-volt portable electric power source. The teletypes are two model 15 (one as a spare) surplus machines, and the facsimile is a continuous-roll model leased from the manufacturer.

FIGURE 1.—Radio-facsimile.

## Advantages of a Mobile Unit

The information received by radio-teletype and radio-facsimile provides the weather forecaster with a look at the broad-scale weather picture. The location, intensity, and movement of large pressure systems (storm, etc.) can be determined from these charts, and the meteorologist uses them to prepare the general forecast for a large area. However, the extremely local forecast that is needed for fire planning requires additional information about the terrain and vegetation at the fire plus local weather

measurements in and about the fire area. The meteorologist gets this information by being on-the-spot at the fire scene.

An additional advantage of the weather unit being at the fire is in the improved communication that results from the close contact between the weatherman and fire boss. The meteorologist is continuously aware of any critical fire problems that exist. He is available for immediate conference at any time. Furthermore, the forecaster participates in fire strategy meetings, where he presents a detailed weather briefing. Thus all principal overhead are made aware of the weather forecast and can plan accordingly.

Often a very useful short-period forecast can be made by judiciously studying local weather signs. For example, the extreme turbulence that accompanies a thunderstorm downdraft can often be anticipated by the trained weather observer. Also, changes in low-level winds can at times be deduced from cloud motions and changes in air mass stability as indicated by the character of a smoke plume. The meteorologist at the fire scene is a trained observer who can use weather signs to best advantage.

Prior to the development of the new mobile weather system, the meteorologist was equipped with a two-way radio hookup with the central forecasting headquarters. This equipment was used to transmit long lists of coded weather reports to the fire. The weather forecaster then spent hours plotting and analyzing this data on weather charts and had little time to study the terrain and vegetation complexes, to make weather measurements, and hence to localize the forecasts. Also, charts prepared in this way were only a meager sample of the many kinds of charts used by modern-day weather forecasters. In addition, under this system communications were often impossible because of the vagaries of fixed-frequency radio, and the forecaster was forced to provide weather advice without benefit of the necessary forecasting tools. Multifrequency radio-facsimile and radio-teletype have solved these problems.

The new mobile unit had its first test run last summer when it was dispatched to the Twelve-Mile Creek Fire in Douglas County, Oreg. Although the weather on this fire was not critical enough to have caused many fire problems after the initial run, the value of the mobile forecasting unit was proved. Radio-facsimile and teletype weather data was being received within one-half hour after the unit arrived at the fire, and fire weather and fire behavior forecasts based on the information were prepared and used immediately for planning fire strategy.

### Portable Weather Shelters

Four portable weather shelters have been designed for use with the mobile unit. These weather stations were designed by the weather section for easy installation about the fire. They provide atmospheric measurements for use in forecasting and for future study of the effects of weather on fire behavior. The instrument package includes a standard recording hygrothermograph, an electric fan-aspirated psychrometer, a wind counter, and a plastic rain gage. These shelters effectively complement the other equipment of the weather van.

## Plans

Theodolite and helium-balloon equipment will be added to the unit as soon as possible. This gear will enable the meteorologist to measure the winds aloft over the fire area, which is an important variable to be considered when making local wind forecasts. In addition, it is hoped that the low-level wind profile thus obtained can be related to blowup conditions in a manner similar to that reported by Byram.[1]

The Oregon State Board of Forestry is investigating the possibilities of establishing a two-way, transmit-receive radio-facsimile system between the main headquarters and the mobile unit. This equipment would enable the headquarter's weather office to transmit to the fire a selection of weather charts that are better suited to local forecasting than the ones currently transmitted by the Navy. In addition, fire progress maps, polaroid photos of the fire, press releases, supply orders, and other communications could be transmitted back to headquarters via the radio-facsimile. Hence, the mobile unit may become a highly valuable tool to the firefighting organization, other than an aid to more accurate weather forecasting.

## Conclusion

The Oregon State Board of Forestry has introduced a new concept to mobile fire weather unit operations. This entails radio-facsimile and radio-teletype. A big advance in mobile unit operations has been made.

1. Communication will no longer be a problem to the meteorologist who is providing on-the-spot fire weather forecasts. Naval weather data is broadcast simultaneously on several frequencies, thereby allowing the receiving station to select the best frequency.
2. More complete and timely weather charts and reports will be available to the forecasters than was previously possible.
3. The home office will be freed of the long job of transmitting raw data to the mobile unit.
4. More time will be allowed the field forecasters to study the effects of local terrain on the weather and to collaborate with the fire behavior specialist.
5. Communication between these two specialists will be greatly improved by having the meteorologist at the fire.
6. This equipment should result in more timely and accurate weather forecasts for use in the planning of firefighting strategy.

---

[1]Byram, George M., In *Forest Fire Control and Use*, by Kenneth P. Davis. Ch. 4, 108 pp. McGraw-Hill. 1959.

# WATER-BOMBING WITH THE DeHAVILAND BEAVER

R. O. STROTHMANN, *Research Forester, Lake States Forest Experiment Station*, and L. J. McDONALD, *Superintendent, Ely Service Center, Superior National Forest, U.S. Forest Service*

In June 1959 the Superior National Forest and the Lake States Forest Experiment Station cooperated in testing the water-drop pattern of a pontoon-equipped DeHaviland Beaver. The plane has been used successfully for several years by the Forest for initial attack on fires and for suppression of small fires.

The plane has a 125-gallon fuselage tank fitted with a snorkel loading tube that extends into the water between the pontoons. With this arrangement the tank can be filled in about 14 seconds while the plane taxies across the surface of any of the many lakes in the area. Thus, a nonstop shuttle service can be operated between a fire and the nearest lake large enough to allow the plane to land and take off.

Twenty water-drop tests were made over a 3-day period at the municipal airport at Ely, Minn. Of these, 14 were with plain water and 6 with "wet" water. The pilot flew at altitudes between 80 and 100 feet and at speeds between 80 and 100 miles per hour (fig. 1). Information on temperature, relative humidity, wind direction, and wind velocity was obtained just prior to each drop.

FIGURE 1.—Water drop from a pontoon-type DeHaviland Beaver.

The average size of the total measurable pattern was 75 by 400 feet. Water volume around the edges, however, was as low as 0.1 gallon per 100 square feet. Under certain circumstances water concentrations of 0.2 or 0.3 gallon per 100 square feet might be of value if dropped on a fast-spreading fire in grass fuels. In most situations, however, the concentration would have to be at least 0.4 gallon per 100 square feet to be of value. On this basis, the dimensions of the Beaver's effective pattern are reduced to about 45 by 150 feet.

The only measured variable that had an unmistakable influence on the amount of water reaching the ground was relative humidity. When relative humidity was high (60 to 70 percent), more than twice as much water reached the ground in concentrations of 0.4 gallon or more per 100 square feet than when it was low (35 to 40 percent). Also twice as much area was covered by the higher concentrations of water when the drops were made under the more humid conditions.

In comparing plain water and "wet" water, the plain water generally covered a larger area and reached the ground in larger quantities. Since the number of "wet" water drops was limited, these findings should not be regarded as conclusive. Observations indicated that the "wet" water remained suspended in the air longer and dispersed into a finer mist.

The amount of water reaching the ground (combining both the plain water and "wet" water trials) averaged 50 gallons, or 40 percent of the total amount released from the plane. At the lower humidities (35 to 40 percent) only about 28 percent of the water released actually reached the ground, whereas at the higher humidities (60 to 70 percent) about 49 percent reached the ground.

The size and shape of the patterns of the Beaver resembled those obtained elsewhere in water-bombing trials with a Stearman and other small planes except that they were measurably longer (up to 100 feet). The big difference was in the concentrations of water reaching the ground. The maximum concentration at the pattern center for the Beaver was about 1.0 gallon of water per 100 square feet, whereas in comparable patterns for the other planes the maximum concentrations exceeded 2 gallons per 100 square feet.

The total area covered was about the same as that reported for a Stearman. The Stearman had the same tank capacity as the Beaver—125 gallons. However, when the Stearman flew at comparable altitudes and airspeeds, the coverage at concentrations of more than 0.5 gallon per 100 square feet was between 6,000 and 7,000 square feet compared with less than one-half this area for the Beaver patterns. On the Stearman patterns, approximately 3,000 square feet received water in concentrations of more than 1.0 gallon per 100 square feet, whereas the Beaver pattern never had more than 400 square feet covered with this concentration.

The one factor largely responsible for the low volumes delivered by the Superior National Forest's Beaver is the size of the release hatch. Tests at the Arcadia Equipment Development Center

show that optimum size of release openings should be about 1,000 square inches per 250 gallons. The opening in the Beaver is a 17-inch circle which provides only about 225 square inches; it is less than one-half the optimum size for a capacity of 125 gallons.

In addition, the effective size of the opening is further reduced because of the design of the release mechanism. This mechanism is two semicircular plates hinged across the diameter of the opening. When opened, the plates do not fall free, but stay partially closed in an inverted "V" position with the apex alined across the diameter of the opening.

In summary, the tactical possibilities of the basic unit are very good. In the lake country of northern Minnesota, the plane can make repeated drops on a target area at short intervals because of the snorkel loading tube which permits filling the tank while the plane taxies across the water. The one big improvement needed is a larger and more efficient release mechanism for discharging the load.

After modifications of the tank release mechanism have been made, further tests of the water-bombing pattern are planned. These will probably include test drops on brush and in timber as well as drops over an open field.

☆ ☆ ☆

## Dozer Spotter's Kit

A canvas packet containing a staple gun, extra staples, and a bundle of cards with squares of reflective tape on one side and arrows of reflective tape on the other has been tested by the Missoula Equipment Development Center, following a suggestion by James E. Wilson of the Lolo National Forest. A red, pressure sensitive tape is used. These reflective cards when stapled to trees make markers that are more visible than tree blazes in daylight or at night. The cards can be removed for relocating courses; blazes cannot. The square designates straight ahead, the arrow, a change in direction.

A card 4 inches square has a 2- by 2-inch square of reflective tape on one side and a 1- by 4-inch arrow of the tape on the other. Cost per card for the reflective tape is 6½ cents.

A card 5 inches square has a 4- by 4-inch square of reflective tape on one side and a 2- by 4½-inch arrow on the other. Cost per card for reflective tape is 16½ cents. The kit is a good addition to any dozer spotter's equipment.—Missoula Equipment Development Center, *U.S. Forest Service, Missoula, Mont.*

# MORE ON AERIAL DROP ACCURACIES

Loyd M. LaMois
*Forester, Division of Forest Fire Research, U.S. Forest Service, Washington, D. C.*

In an article in Fire Control Notes (April 1961) the author explored, rather superficially, the logistics of air attack on forest fires. The assumption of "randomness" was called to question in cases where aim was primarily dependent upon pilot judgment. It was suggested that over a series of successive drops on a fire the distribution of retardant patterns about the target may *not* be of a random nature—that corrective action on the part of the pilot may result in pattern distributions from which predictions of success cannot be made under the assumption of random error.

The question remains, then; "how random are errors resulting from pilot judgment?"

The author cited a series of test drops in Montana during 1947. As reported in the article, the distribution of absolute errors in range was described almost perfectly by a frequency curve of the exponential form: $p = ae^{-ax}$ where "$p$" is the probability of a pattern center being within "$x$" feet of the target point, and "$a$" is the reciprocal of the mean absolute error.

Subsequent analysis of the complete report of these tests revealed a rather upsetting fact. *The twenty-one test drops were not made during a single day;* rather, they were made on separate occasions consisting of *two successive drops per trial.* Aside from the fact that the author's account of these trials may have been misleading in context with the FCN article, this new discovery allowed for a quick check on the nature of corrective action by a real, alive pilot in northern Montana.

On eight of the occasions where two successive drops on the fire target were made, significant differences in the placement of the drop patterns resulted from adjustment in aim. On *three* of these occasions placement of the second pattern resulted in improved coverage of the fire target. On *one* occasion overcorrection led to placement of the second pattern farther from the target than had been the initial drop—on the other side of the target. On all the remaining *four* occasions the second drop was farther from the target on the same side—a complete failure in corrective action.

In summarizing the above observations, it is noted that in only 50 percent of the cases did corrective action result in shifting pattern coverage in the *proper direction.* While there is no statistical proof that correction of aim is unattainable in this type of operation, the results here show that *within certain accuracy limits* there probably is a large element of "randomness" in the results of corrective action by glide bomb pilots.

A further modification of observations on the Montana tests results from the fact that these tests were made with 165-gallon drops of "*contained*" water. In developing the prediction formula, the absolute error of any single drop was computed to be the distance from the target to the point of impact, as recorded in their tabulated results. The author assumed that aiming a tank of water at a fire was the same thing as aiming the "center" of a free-drop pattern at a fire.

Apparently the pilots fell into the same error—impacting seven of their tanks within 20 feet of the fire. Four of these, being overshots, were completely wasted. Two more were right on target—wasting most of the pattern.

At any rate, the distribution of these patterns about the target was re-examined with respect to the pattern centers instead of impact point. Lo and behold, when the probability of any single pattern center being within a specified distance from the target was computed, the prediction was according to the *normal curve* of errors—a more conservative estimate than that arrived at via the exponential formula.

In final comment, then, evidence which would tend to indicate the random nature of pilot aiming errors, and at the same time bear witness to the Gaussian, or normal, distribution of those errors, serves to simplify and substantiate some of the author's original speculations on this problem. In addition, it points out that there is much we can learn, through experimentation, about dropping accuracies in air attack.

☆ ☆ ☆

## Safety In Fire Retardant Drop Areas

Fire retardant dropping from an airplane can be dangerous for those on the ground. To reduce the hazard, the U.S. Forest Service is issuing instructions for people who may arrive at a fire ahead of regular Forest Service personnel. One man was killed in the West last summer and others have been injured when they were hit by a load from a low flying, fast moving plane.

The Forest Service TBM bomber can be easily recognized. It is a midwing, single engine plane with stubby, thick fuselage. It will circle the fire and then make one pass over it. This pass is the line of flight for the "drop." The drop is made on the second pass, with the drop pattern about 300 to 500 feet long and 75 feet wide at the center.

When the plane makes its first pass, personnel are cautioned to move at least 150 feet to one side. Anyone trapped and in danger of receiving the full force of the load should lie face down flat on the ground with the head in the direction of the oncoming plane. If possible, he should lie directly behind a tree and wrap his arms around it. No one has been injured by the sheer force of the blow, but men have been knocked over cliffs or thrown up against trees or rocks.

# PENNSYLVANIA'S INITIAL AIR ATTACK OPERATIONS—SPRING 1960

Samuel S. Cobb,
*Division of Forest Protection, Pennsylvania Department of Forests and Waters*

During the spring of 1960, the Division of Forest Protection of the Pennsylvania Department of Forests and Waters conducted experiments in the use of aircraft in direct attack as a fire suppression tool. Both fixed wing aircraft and helicopters were tested.

The basic objective for the air attack program was initial attack on any fire within the effective operational range of the equipment at the earliest possible moment. The aim was to achieve the initial water drop when the fire was small enough for the drop to prevent a strong run before ground forces arrived. It was not assumed that complete suppression would result from air drops and the normal fire control organization was continued on the existing pattern.

When the incidence and timing of fire starts within the operational area permitted followup drops on a fire, or when large or dangerous fires within the general area of the air operation occurred, two secondary objectives were recognized: (1) On large fires aircraft could be used for holding action to permit assembly of sufficient ground control personnel and construction of control lines. (2) Where exceptional property values were threatened, timber or other, drops could be made to protect them.

All high fire incidence areas of the State were plotted for the past 5 years and the two worst areas set up as operating units to be serviced during the spring of 1960. These two units centered at Hazleton City in the east-central anthracite coal mining area and at Black Moshannon on the eastern rim of the Allegheny Mountains in west-central Pennsylvania.

To achieve useful initial attack, as determined on the basis of the performance characteristics of the aircraft to be used, the water volumes available, and the rate of fire spread for average conditions in Pennsylvania, operational circles of 20-mile radius for the airplane and 15-mile radius for the helicopters were set up.

In actual practice under normal flight conditions these proved to be generally correct. The helicopter was subject to greater fluctuations in speed due to wind direction and velocity than was the airplane.

The airplane used was a Stearman A75N, with a cruise speed of 110 m.p.h. This two-place biplane with open cockpit was modified by installing a 180-gallon tank with drop gates in the area occupied by the front cockpit. About 150 gallons was found to be the maximum safe operating load.

The helicopters were Bell 47 G models. These are a two-place, bubble canopy type with an operating speed of 60 m.p.h. One ship

was rigged to carry a 35- or 50-gallon coated fabric bag attached to a cargo sling beneath the copter. The other ship carried two aluminum side tanks connected by an equalizing pipe and equipped with three drop valves. The tanks were attached like saddle bags on each side of the fuselage, just behind the bubble and motor mounting. The volume carried by this unit was 60 gallons.

The airplane worked the Black Moshannon Unit for 2 weeks while one helicopter worked the Hazleton Unit. The airplane then shifted to Hazleton, the second copter unit moved into Black Moshannon, and the copter at Hazleton moved to a third experimental area in the Pocono Mountain area. Then a second 2-week operation was conducted.

The control center must be convenient to the aircraft service area to allow for rapid communication and consultation between the pilots and the control center chief. It should be large enough to permit installation of a desk, a sizable map, radio, telephone, and other necessary equipment.

Radio and telephone communications are essential to insure immediate receipt of smoke sighting reports from towers and for communication with the normal fire control organization when information or coordination of action is required.

For the airplane a reasonably good airfield is required. Gas and oil supplies are mandatory, repair facilities desirable. The service area should be at sufficient distance from the airport building to eliminate interference with its normal operation, but close enough to avoid loss of time in operational servicing. Basic personnel are the control center chief and the pilot. Where the control center is any distance from the water service location, an additional man is necessary to operate the pump. A suitable pump should be fitted for instant and rapid loading. A tank of 1,000-gallon minimum capacity should be provided and arrangements made to keep it filled at least twice daily under extreme conditions.

The helicopter can be operated from any clear, level area suitable for safe takeoffs and landings. A heavy sod or surfaced ground cover to eliminate dust is highly desirable. An established airfield is preferred, however, to insure adequate servicing (gas and oil) for the 'copter. Because of the noise of the 'copter the operation area should be some distance from the airport service buildings. Basic personnel where coated fabric bags are used would be the control center chief, the pilot, and a man to handle the hose from the pump. If the control center is not adjacent to the service area, an additional man to operate the pump is required. A hose man is not required for loading side tanks. A water storage tank of not less than 500 gallons is required; it should be filled at least twice daily.

During the 1960 operations the airplane flew a total of 54 missions. In all, 115 drops were made and 15,000 gallons of water used. In about 90 percent of these drops the results were considered to be helpful in the control action. In several instances the fire was completely extinguished.

The Hazleton operation was typical of all helicopter operations. Fifteen fire missions were flown, 27 drops were made, using 1,070

gallons of water. Results were considered to be of value in assisting in the control of the fires in about 60 percent of the missions. Two cases of complete extinction were recorded.

Helicopters were also used in a number of types of control action other than water drops. Scouts and the fire boss were flown over several large fires for reconnaissance purposes. Firefighters with backpack pump cans and fire rakes were taken in to ten fires in the Hazleton area. After some fires were controlled men and tools were recovered by 'copter. Food and water were taken into inaccessible areas on several large or remote fires. Fires were surveyed and fire control personnel taken on flights to familiarize them with certain areas.

Tentative arrangements have been made to expand the airplane operations to five units on a one-month, simultaneous basis during the spring fire season in 1961. One helicopter is planned for use in the Pocono Mountain area. Another 'copter may be placed under contract for general and emergency use statewide.

## Observations

The airplane was considered to be highly successful as an initial attack weapon to hold fires in check pending ground attack. To achieve this success dispatch must be immediate on any smoke sighted. Efforts to identify smoke cause before dispatch of the plane only serve to reduce the effectiveness of the first drop because of additional elapsed time from start to attack and consequent increase in fire size. The airplane also showed promise when used to hold dangerous portions of line on large fires.

Slower speeds and low water carrying capacity of helicopters limit their effectiveness. Self-loading facilities to utilize water sources close to fires and elimination of time consuming flights to and from the control center would increase helicopter effectiveness. Their maneuverability and ability to land in a restricted space make them useful tools if water supply problems can be solved. Their usefulness in fire scouting and transporting men, equipment, and supplies also makes them excellent control tools where they are available or where fire incidence warrants their use on a standby basis.

# HOT MEALS FOR FIREFIGHTERS

JOHN D. WHITMORE, JR., *Fire Control Officer, Glenwood District, Jefferson National Forest*

Providing food for firefighters is a most important job—appetizing, nourishing, and well-scheduled meals restore energy and maintain high morale. But, as most everyone knows, this job is usually laden with problems.

The Glenwood District has successfully solved its feeding problems by having food prepared by a caterer and delivered at or near the fire by car or pickup truck. This food service is provided by the Bureau of Prisons which operates a camp for juveniles on the district. They have been most cooperative. We furnished their kitchen force with two basic menus and explained the use of our containers, including the nesting and storing of all components. As soon as a fire is manned, we call the prison camp and request "a stew meal or a chili meal for 10 men." Even if the request were for food for 100 men, the fire boss could expect the food to be on its way to the fire in 3 to 4 hours.

Providing hot food prepared and delivered by a caterer—

1. Gives all firefighters hot, nourishing meals on schedule.
2. Eliminates the need for cooking facilities and food preparation at the fire.
3. Returns the men as quickly as possible to the fireline after a meal without tying up supervisory personnel.
4. Relieves the fire boss of detailed food arrangements.
5. Keeps food costs in line with other aspects of the total fire-suppression job.

For this system to work successfully, detailed arrangements with a restaurant or other caterer are necessary. Hot food containers should be furnished the caterer, as well as other necessary service equipment. Our equipment is assembled in 25-man units (fig. 1).

We use menus of beef stew and chili because they are easily prepared and furnish a well-rounded meal; they are also acceptable to nearly all firefighters. For 10 men, they are as follows:

| *Beef Stew* | | *Chili* | |
|---|---|---|---|
| 2½ | lbs. diced beef | 1½ | lbs. kidney beans |
| 5 | lbs. potatoes | 3 | lbs. ground beef |
| 1 | lb. onions | ½ | lb. onions |
| 1 | stalk celery | 1 | cup catsup |
| 1 | lb. carrots | | |

Either of these menus is accompanied by

| | |
|---|---|
| 3 loaves of bread | 10 apples, oranges, or bananas |
| 2 gallons of coffee | 1 pound of cookies |

Each spring we conduct a daylong training session for key wardens and cooperators. One man has the responsibility of directing the feeding of others. At noontime the trainees are given one of our "catering service meals," and our field service equip-


FIGURE 1.—Food service equipment for 25 men: *Top left*, 4¾-gallon hot-food container; *top right*, 2-gallon coffee container; *bottom*, box for dishes, cups, spoons, bowls, bread, fruit, and cookies.

ment is used. This demonstrates to our cooperators how many of the problems of feeding firefighters can be eliminated by a catering service, and also what their crews can expect at mealtime when they participate in fire suppression on the Glenwood District.

☆ ☆ ☆

## Colville Smokey Danger Meter


Smokey Bear shows visitors the fire danger for today (current 24-hour period) on the Colville National Forest. Smokey is about 7 feet tall and has a moveable arm.

This life-size sign stands on the front lawn of the Colville Ranger Station at Colville, Wash., next to U. S. Highway No. 395. The same information appears on both sides of the sign so travelers in either direction can quickly read the fire danger for the day.

The sign was designed and constructed by Bob Lynds, Fire Control Aid on the Colville District, and Mickie Lewis, Payroll Clerk in the Supervisor's office.—E. Arnold Hanson, *Northern Region, U.S. Forest Service.*

## INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.


GROWING TIME- MANY YEARS
BURNING TIME-
ONE CARELESS MOMENT
SMOKEY
Remember– ONLY YOU CAN PREVENT FOREST FIRES!

VOL. 22 APRIL 1961 No. 2



# FIRE CONTROL NOTES

A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL



FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1962

Growth Through Agricultural Progress

Volume 22 Number 2

# FIRE CONTROL NOTES

## A Quarterly Periodical Devoted to the

## TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (October 17, 1958).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1961

# CONTENTS

# DROPPING ACCURACY—A LOGISTICS PROBLEM IN AIR ATTACK

LOYD M. LAMOIS, *Forester, Division of Forest Fire Research, U.S. Forest Service, Washington, D. C.*

Promising breakthroughs in technology are sometimes exploited at a pace which for a short period of time carries them ahead of underlying theories. Seldom, however, is this lop-sided race between practice and theory a long one. Sustained progress to high levels of achievement is a longer run—with basic theory setting the pace.

A case in point is the air attack of forest fires. In seeking for refinement and dependability in the air delivery of fire retardants we should pause to examine some fundamental aspects of the delivery process—aspects which not only will yield clues to more effective use of the tools we have at hand, but also will help us choose correctly from alternative approaches to the problems of designing new equipment.

Aside from the tactical decisions involved, the effectiveness of any single delivery of retardant to the fire site is a function of *pattern size* on the ground and the *accuracy* of placement. The interplay between these two variables defines the limits within which we must work. We cannot "engineer" larger patterns at too great a sacrifice in delivery accuracy. On the contrary, we dare not launch a program to develop pinpoint delivery if the mechanics threaten to restrict ground pattern size to that which would offset the gain in accuracy.

In the evaluation of a proposed delivery system, of course, the "effectiveness measure" of any single delivery must be considered along with the *costs* involved in operating the system. These three parameters, then, form the matrix of values within which our engineers must work to make the proper choice of delivery vehicle, aiming system, release mechanism, and operational tactics.

## ACCURACY

Accuracy concepts are the logical starting point for much of the basic work to be done in the building of a sound air-attack methodology. The proper choice of equipment and its tactical use depend upon accuracy estimates which allow us to predict, with some degree of certainty, the ratio of probable successes to number of tries.

Unfortunately, we know very little about the accuracies we are obtaining with present equipment and present tactics. Experience has given us a general "feel" to serve as a rough guide; but we have few quantitative data on drop accuracies and precisely

how they may vary with altitude, flight speed, tactical situation, human factors, etc. We have even less information on the level of accuracies obtainable with other modes of delivery such as high altitude drops of contained retardants, guided missiles, rocketry, etc.

To illustrate how such information might be of use to an air dispatcher, we will consider two tactical situations. The first is a mission to treat a lightning-struck snag which is smouldering and might become the start of a going fire if left unattended. The second is a line-building mission in which retardant is to be laid down in advance of a moving fire front or along an extended flank.

Against a background of considerations involving flying safety, time factors, and control tactics the dispatcher must answer two logistics questions immediately: (1) which delivery vehicle can best do the job? and, (2) how many drops can we expect to need in order to accomplish the mission? The following discussion illustrates an approach toward finding answers to these questions.

## AIR DELIVERY TO A POINT TARGET

To evaluate the probability of success on any single delivery mission we must have some notion of how a number of similar deliveries are likely to be distributed about the target. Immediately we are forced to make an assumption that over a large number of similar drops the centers of the individual drop patterns on the ground will be clustered about the true target point, and not about a false point of aim significantly distant from the true target, i. e., we are dealing with random error.

This assumption is a logical one in the case of low-level glide water drops, where the pilot (as a flesh and blood servomechanism) is constantly adjusting his aim from the results of his previous drop. It also would be the logical assumption for a guided missile type of delivery, where true aim is assured and errors are purely mechanical ones inherent in the flight characteristics of the missile. This assumption would also hold true for high-altitude bombing with an accurate bomb sight and sources of systematic error, such as wind, taken care of.

In most situations this distribution of pattern centers will be such that the frequencies of occurrence, as one moves farther from the target, are arrayed according to the Gaussian or normal curve of errors.[1]

We need, however, more experimental data in order to safely assume random error where aiming is predominately a matter of judgment on the part of the pilot. We need, also, data upon which to base estimates of *mean absolute error* (average distance from

[1] In the case of low-level glide bombing this last assumption apparently does not hold true. Analysis of results involving 24 individual drops on a point target from a P-47 aircraft in Montana shows that the distribution of pattern centers about the target was predicted best from an exponential curve of errors. Successive corrections by the pilot in this type of action apparently results in early wide misses being quickly reduced to a high order of accuracy. The graph of frequencies becomes one in which a sharp peak of occurrence is centered on target, then falls off quite rapidly to the point of mean absolute error and extends far out in a long tail resulting from early large errors.

target to pattern center),[2] associated with various tactical situations, different delivery vehicles, and, in the case of manned aircraft, individual pilots.

Knowing the mean absolute error and assuming a given distribution of pattern centers about the target, one can calculate the probability of any single pattern center being within a specified distance from the target point. With the ground dimensions of effective pattern known, this probability data can be arrayed into graph or chart form that will yield the probability of any single delivery resulting in a ground pattern which includes the target point.

This has been done for both of the aforementioned error distributions. Table 1 assumes the normal distribution about the target. Table 2 assumes an exponential error distribution of the form

$$p = ae^{-ax} \text{ where } a = \frac{1}{\text{m.a.e.}} \text{ and } x = \text{distance from target.}$$

TABLE 1.—*Probability of target being covered by drop pattern*[1]

[Percent]

| Mean absolute distance off target (feet) | Probability when dimension of drop pattern[2] in feet is— | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 100 | 160 | 240 | 320 | 400 |
| 10 | 44 | 57 | 68 | 77 | 89 | 95 | 98 | 99 | 99 | — | — | — | — |
| 20 | 22 | 30 | 37 | 44 | 57 | 68 | 77 | 89 | 95 | 99 | 99 | — | — |
| 30 | 15 | 19 | 24 | 30 | 40 | 49 | 57 | 71 | 82 | 96 | 98 | — | — |
| 40 | 11 | 15 | 18 | 22 | 30 | 37 | 44 | 57 | 68 | 89 | 98 | 99 | 99 |
| 50 | 09 | 12 | 15 | 18 | 24 | 30 | 35 | 47 | 57 | 80 | 94 | 98 | 98 |
| 60 | — | 10 | 13 | 15 | 19 | 24 | 30 | 40 | 49 | 71 | 89 | 96 | 97 |
| 80 | — | — | 09 | 11 | 15 | 18 | 22 | 30 | 37 | 57 | 77 | 89 | 95 |
| 100 | — | — | — | 09 | 12 | 15 | 18 | 24 | 30 | 47 | 66 | 80 | 89 |

[1] Assumes normal distribution of absolute errors.

[2] Dimension is pattern *length* when range error is under consideration. It is pattern *width* when considering deflection error. With circular patterns, dimension would simply be the pattern *diameter* in both cases.

When deflection errors are negligible (often the case with low-level glide bombing), the probability of target coverage is a matter of range error alone, and the table need be entered only once. When errors to the left or right of flight line are large enough for concern, the table must be entered twice—once for target coverage along the flight path and once for target coverage lateral to the flight path—and the resulting two probabilities multiplied to obtain net probability of target coverage.

A comparison between the two tables shows that the assumption of normal error distribution yields a more conservative estimate of success probabilities with pattern dimensions less than 300 feet. With pattern dimensions of more than 300 feet, probability values are approximately equal.

[2] Mean absolute error as used in this article is not the average *radial* distance from target to pattern center. It is, rather, the individual range component or deflection component as the case may be.

TABLE 2.—*Probability of target being covered by drop pattern*[1]

[Percent]

| Mean absolute distance off target (feet) | Probability when dimension of drop pattern[2] in feet is— | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 20 | 25 | 30 | 40 | 50 | 60 | 80 | 100 | 160 | 240 | 320 | 400 |
| 10 | 53 | 63 | 71 | 77 | 86 | 91 | 95 | 98 | 99 | — | — | — | — |
| 20 | 31 | 39 | 46 | 53 | 63 | 71 | 77 | 86 | 91 | 98 | — | — | — |
| 30 | 22 | 28 | 34 | 39 | 49 | 56 | 63 | 73 | 80 | 93 | 98 | 99 | 99 |
| 40 | 17 | 22 | 27 | 31 | 39 | 46 | 53 | 63 | 71 | 86 | 95 | 98 | 99 |
| 50 | 13 | 18 | 22 | 26 | 33 | 39 | 45 | 55 | 63 | 80 | 90 | 96 | 98 |
| 60 | 11 | 15 | 18 | 22 | 28 | 34 | 39 | 49 | 56 | 73 | 86 | 93 | 96 |
| 80 | — | 11 | 14 | 17 | 22 | 27 | 31 | 39 | 46 | 63 | 78 | 86 | 91 |
| 100 | — | 09 | 11 | 13 | 18 | 22 | 26 | 33 | 39 | 55 | 69 | 80 | 86 |

[1] Assumes exponential distribution of absolute errors.

[2] Dimension is pattern *length* when range error is under consideration. It is pattern *width* when considering deflection error. With circular patterns, dimension would simply be the pattern *diameter* in both cases.

When the probability of target coverage is determined, it is possible to estimate the number of deliveries needed to assure success within certain confidence limits (table 3). This sort of logistics information could be of real value to a ground crew preparing to service a suppression mission and who would benefit from even a rough estimate of probable needs in the ways of gallons, missiles, aircraft, etc.

## LAYING DOWN A FIRE BARRIER

The logistics of line building can be explored in a similar manner—a theoretical approach serving to lay a conceptual framework within which practical considerations might be examined.

One set of delivery assumptions from which we might begin could be the following:

1. Deflection error insignificant.
2. Range error known.
3. Absolute errors in range distributed normally about target point.

If our delivery system would allow us to build line by aiming at a succession of point targets laid out in advance of a fire, our above assumptions can tell us how these targets should be spaced and also indicate scheduling of drops on each target. For any given mean absolute error (range) and corresponding pattern length on the ground, table 4 lists the distance between successive target points that is necessary to be "95 percent sure" of overlap between drop patterns on the ground.

Table 4 displays two values in most cases. The upper value is the distance between successive targets when *one* delivery is made at each target point. The lower figure is the distance between successive targets when *two* deliveries are made at each target point. For any given accuracy value, the shorter pattern lengths on the ground demand at least *two* deliveries at each target point to allow for measured advance with 95 percent probability of no gaps in

TABLE 3.—*Estimated number of deliveries at a point target*

| If your chances for success are— | Use this many tries to be 95 percent sure of at least one success | To be 99 percent sure, use this many tries |
| --- | --- | --- |
| 0.99-1.00 | 1 | 1 |
| .95- .99 | 1 | 2 |
| .90- .95 | 2 | 2 |
| .80- .90 | 2 | 3 |
| .70- .80 | 3 | 4 |
| .60- .70 | 4 | 6 |
| .50- .60 | 5 | 7 |
| .45- .50 | 6 | 8 |
| .40- .45 | 6 | 10 |
| .35- .40 | 7 | 11 |
| .30- .35 | 9 | 13 |
| .25- .30 | 11 | 16 |
| .22- .25 | 13 | 20 |
| .20- .22 | 14 | 21 |
| .18- .20 | 17 | — |
| .15- .18 | 19 | — |
| .13- .15 | 22 | — |
| .10- .13 | 24 | — |

TABLE 4.—*Line-building aiming schedule for 95 percent probability of overlap*[1]

| Mean absolute error (feet) | Distance in feet between successive target points[2] when pattern length in feet is— | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | 20 | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 160 | 200 | 250 | 300 | 350 | 400 |
| 20 | — | — | 2 | 12 | 22 | 42 | 62 | 82 | 122 | 162 | 212 | 262 | 312 | 362 |
| | 16 | 26 | 36 | 46 | 56 | 76 | 96 | 116 | 156 | 196 | 246 | 296 | 346 | 396 |
| 30 | — | — | — | — | 3 | 23 | 43 | 63 | 103 | 143 | 193 | 243 | 293 | 343 |
| | 14 | 24 | 34 | 44 | 54 | 74 | 94 | 114 | 154 | 194 | 244 | 294 | 344 | 394 |
| 40 | — | — | — | — | — | 4 | 24 | 44 | 84 | 124 | 174 | 224 | 274 | 324 |
| | 12 | 22 | 32 | 42 | 52 | 72 | 92 | 112 | 152 | 192 | 242 | 292 | 342 | 392 |
| 50 | — | — | — | — | — | — | 5 | 25 | 65 | 105 | 155 | 205 | 255 | 305 |
| | 10 | 20 | 30 | 40 | 50 | 70 | 90 | 110 | 150 | 190 | 240 | 290 | 340 | 390 |
| 60 | — | — | — | — | — | — | — | 6 | 46 | 86 | 136 | 186 | 236 | 286 |
| | 8 | 18 | 28 | 38 | 48 | 68 | 88 | 108 | 148 | 188 | 238 | 288 | 338 | 388 |
| 70 | — | — | — | — | — | — | — | — | 27 | 67 | 127 | 177 | 227 | 277 |
| | 6 | 16 | 26 | 36 | 46 | 66 | 86 | 106 | 146 | 186 | 236 | 286 | 336 | 386 |
| 80 | — | — | — | — | — | — | — | — | 8 | 48 | 98 | 148 | 198 | 248 |
| | 4 | 14 | 24 | 34 | 44 | 64 | 84 | 104 | 144 | 184 | 234 | 284 | 334 | 384 |
| 90 | — | — | — | — | — | — | — | — | — | 29 | 79 | 129 | 179 | 229 |
| | 2 | 12 | 22 | 32 | 42 | 62 | 82 | 102 | 142 | 182 | 232 | 282 | 332 | 382 |
| 100 | — | — | — | — | — | — | — | — | — | 10 | 60 | 110 | 160 | 210 |
| | — | 10 | 20 | 30 | 40 | 60 | 80 | 100 | 140 | 180 | 230 | 280 | 330 | 380 |

[1] Assumes *no* deflection error.

[2] Upper value indicates target advance with *one* delivery per target.
Lower value indicates target advance with *two* deliveries per target.

Within the boldfaced portion of the table the *net* rate of line building will be greater if single drops are used at each target. In the lightfaced portion of the table, two drops per target point are necessary for maximum progress in line construction. For extremely short ground patterns and large error in accuracy three drops per target would provide maximum rate of line building. Just where this is the case has not been defined in the present computations.

the line. As pattern lengths become larger, measured advance can be made allowing for only *one* delivery per target with equal likelihood of pattern overlap. At a certain minimum length of ground pattern (or a certain maximum error) it becomes advantageous to shift from a two-drop delivery schedule with accompanying larger shift in target points to a single-drop delivery schedule with an accompanying smaller advance of target point.

This aiming procedure is, of course, just one of several tactical approaches to line building. How would it compare in regard to efficiency with the alternative tactic of aiming each delivery at the end of the previous one on the ground is a question which might be answered by *simulation techniques.* Knowing the accuracy and pattern size on the ground it is possible to simulate, on paper, a line construction mission which assumes that aim is to be taken on the end of the previous drop pattern. A number of runs, or simulations, should provide a comparison of probable line-building rates between this and other alternative aiming schemes. The outcome of any comparison would depend, again, on the accuracies involved and the pattern size considered—with some combinations favoring one tactic and others favoring an alternative.

## SUMMARY

The exploration of two tactical situations outlined in this paper merely illustrates an approach to the problems involved in air delivery of water and chemicals to the fire site. It does not represent an answer to any single problem. The tables, however, can be used as rough guides to the logistics of present-day air attack if full advantage is taken of what we already know about pattern sizes and drop accuracies.

We need more experience data on actual trials to round out a framework of theory upon which to base practical decisions. Specifically we need to know what order of accuracies are involved and how they vary with: speed of aircraft; altitude of aircraft; aiming systems and devices; human factors, including individual pilot reactions; the type of delivery missile, including self-propelled and self-guided.

A number of hypothetical situations which we may set up on paper might lead us to the conclusion that a system vastly different from the "seat-of-the-pants" style of free water drop we now use is the logical answer to safe and efficient delivery of water or other chemical to the fire site.

# COOPERATIVE AIR ATTACK PROGRAM IN UTAH

RICHARD P. KLASON, *Assistant State Forester,*
*Utah Department of Forestry & Fire Control*

Early attempts at getting an air tanker program operating in Utah were made by our Department in 1958. During suppression operations on a large and stubborn brush fire at Camp Williams, a National Guard training camp south of Salt Lake City, a tank-equipped TBM plane was used to make several air drops. Results were not successful, for several reasons. Air-to-ground communication was lacking, water was being used as the suppression agent, funds for adequately equipping the program were unavailable, and trained personnel were lacking. The most important lesson we learned from the operation on the Camp Williams Fire was that a small agency such as ours would have trouble establishing a workable air attack program.

With the lesson learned at Camp Williams in mind, our Department discussed with the U.S. Forest Service, Bureau of Land Management, and local government agencies the need for and the best method of operating an aerial suppression program in Utah, especially on the Wasatch Front. As a result of these discussions a cooperative program was agreed upon and put into operation in June 1960. Three agencies were primarily responsible for the program, the U.S. Forest Service, Bureau of Land Management, and the Utah Department of Forestry & Fire Control.

These organizations negotiated with a Salt Lake flying concern to handle the actual flight operations. It was decided to have one tank-equipped TBM available on standby from June 15 to September 15. The plane was to be available 7 days a week from 10:00 a.m. to 6:00 p.m., airborne 10 minutes after being notified. A minimum guarantee of $2,500 was agreed upon to meet the operator's expense in the program. The U.S. Forest Service assumed responsibility for 50 percent of the guarantee, the Bureau of Land Management and the State Forestry Department each assumed 25 percent. It was further agreed that each agency would pay the mixing crews for their suppression time. The guarantee for the airplane was to be charged to the using agency at not more than $250 per hour of flight time. Any of the guarantee that was not used by the end of the season would be prorated among the three agencies. The State Forestry Department represented the interests of Salt Lake City's Water and Fire Department as well as the Salt Lake County Fire Department in the agreement.

Each of the using agencies was responsible for providing radio communications for the program when the plane was operating under a given agency's control. To accomplish this the plane was equipped for quick installation of a back-pack type portable radio with the using agency's frequency for air-to-ground control.

The mixing and loading site was established at the Salt Lake Municipal Airport, adjacent to our Department headquarters building. Telephone communications were extended from our office to the loading site to provide better control and alert the pilots. Our equipment supervisor was trained as "mixmaster" and was generally on hand to supervise mixing and loading operations.

The U.S. Forest Service provided much of the equipment necessary to begin operations. Initially, an injector-type portable bentonite mixer was used. Water for mixing was not a problem; a city fire hydrant stood approximately 100 yards from the mixing area. The mix was ¾ pound of bentonite to 1 gallon of water. To obtain sufficient water pressure to operate the mixer efficiently it was necessary to incorporate a booster pump into the system. The booster equipment, as well as the mixing crew, was provided by the Salt Lake City Fire Department and operated under the supervision of the "mixmaster."

Tank trailers were obtained to store the mixed slurry and one trailer was equipped with a high volume transfer pump to load planes. Later the U.S. Forest Service obtained a trailer-mounted bentonite slurry mixer. This unit had a self-contained pump which eliminated the need for the booster pump. In addition the unit would store approximately 1,000 gallons of bentonite slurry and was capable of loading planes. By the end of the season we had a storage capacity of 4,500 gallons of bentonite slurry on the operation site. Also, facilities were expanded so that it was possible to load two planes simultaneously. An additional supply of dry bentonite was stored on the site in a van-type trailer. Reserve supply of bentonite was always on hand at the U.S. Forest Service warehouse, approximately 2 miles from the operation.

As the fire season progressed it rapidly became more severe than normal. The contractor was able to equip two additional TBM's with tanks, increasing our striking force considerably. It became the practice to dispatch two planes on nearly all fire calls. This increased the expense but gave even greater increases in effectiveness in controlling the fires.

The program has proved to be quite effective. Plans are not complete for this season but it is hoped that the cooperative nature of the operation will be continued. In the discussion stage for next summer is a portable unit complete with a storage trailer that could be used in outlying areas. This appeals to all the cooperating agencies as areas that can be reached economically from the Salt Lake Airport are only a small portion of the total protection job in Utah.

# OPERATION HANGAR DOOR

GEORGE ZAPPETTINI, *State Forester*; JOHN L. ARTZ, *Deputy State Forester*; and HOWARD REEDER, *Pilot; Nevada Division of Forestry*

The Toiyabe National Forest, the Bureau of Land Management, and the Nevada Division of Forestry work closely on fire protection and control, including operating air tankers. For the 1960 fire season, the Toiyabe and the BLM contracted for a 600-gallon TBM, with the Division furnishing its 300-gallon C-45. Both aircraft were stationed at the Carson City, Nev., airport for initial attack.

Under a joint Air Operations Cooperative Agreement each agency used both tankers, while using other planes for spotting and guiding. Large-scale fire operations were flown from the larger Minden Airport 11 miles south of Carson City. When required, additional tankers were brought in from out-of-State bases.

Within recent years, air tanker delivery of fire retardants has progressed beyond the pioneering stage. In our own region, western Nevada, the air tanker is most successful in initial attack. There is, however, no reason why the air operation should not be screened to find other air tanker uses—strategic as well as tactical.

If fire control people are to make continuing progress, a policy of research, critique, and training must be maintained. This is the thinking that motivated the annual joint training exercise conducted by the three agencies. When past fire season air operations were analyzed and certain problems were found to be worth further research, an early season air tanker training exercise was planned. Called Operation Hangar Door, it was to consist of a one day fly-out, graded and evaluated from the air and the ground, with all agencies participating.

A typical problem, one of many that were criteria for the research phase of the exercise, follows: The fire is on the north side of Genoa Canyon at 7,000 feet, fuel is second-growth pine, and the fire—grown to 5 acres—is moving rapidly. The terrain is rugged, with slopes of about 45°. It will take more than an hour to bring in ground crews.

The answer seems to be to commit air tankers; the order is given for their dispatch. Two C-45's make drops across the crest of the fire. One party, moving up the slopes, has reached this area and can contain the front; the tankers are ordered to the left flank. However, what was right for the tankers just a quarter mile to the east is proving troublesome on this downhill target. It seems the only approach is from over the higher ridge and straight down the inside face of the canyon. This is not so good for several reasons: Genoa Canyon is on the lee side of the Sierra Nevadas where westerly wind gusts at the ridgetop vary the

tanker's air speed by as much as 50 miles per hour. The wind also flattens the convective smoke columns, trapping smoke within the canyon and producing near zero-zero visibility. Once across the ridge, the steep downhill course pushes the airplane to speeds "in the red" with about 2,000 gravity horsepower at work on the plane, even with its engines fully throttled.

The following questions are based on this problem. They are concerned with safety, economics of the air tanker as a tool under these circumstances, and morale of air and ground crews. These questions, and others extracted from other problems, were worked into the exercise by Jack Artz, Deputy State Forester; and Howard Reeder, Division First Pilot and Air Service Manager.

In the preceding problem, is it reasonable to expect accuracy of the pilot when his approach has been from beyond the ridge and, with the target in sight, he has only seconds to make his final alinement? Can he aline at all, with the visibility as it is? Isn't there a safer technique than to fly a plane at only 75 feet over a wooded ridge, at reduced flying speeds, under gusty conditions? Should the fire boss, out of regard for safety, ground the planes?

With this background and to simulate, as nearly as possible, the actual operational conditions of our rugged mountain area, a site for the exercise was selected in the upper bowl of Vicee Canyon, 5 miles west of Carson City. Three targets were marked with high-visibility bunting at an elevation of 8,000 feet. There is a higher ridge at about 9,000 feet, directly behind the target area.

*Target One:*—A small fire is burning uphill and spreading rapidly in heavy manzanita. A north-south jeep trail at the upper end offers a temporary fireline. The plane makes a drop on brush to the west side of the jeep trail in order to curb the fire before it reaches the jeep trail. Approach is from over an adjacent stand of trees, which are about 75 feet high. The drop is graded for uniformity, width, and length of coverage.

*Target Two:*—Lay a line between heavy manzanita fuel and adjacent stands of fir and pine. The drop, on the left flank of the fire, is slalomlike, downhill from west to east. It begins at the jeep trail 1,000 feet below the ridge, and continues down the 45° slope for another 500 feet. Grading criteria are as for target one, with special emphasis on maintaining airspeeds below 125 m.p.h. at drop.

*Target Three:*—This is a spot fire on a steep sidehill, set by lightning and consisting mainly of a burning snag. The drop is made in a manner that concentrates the entire load on the small area; it is graded accordingly.

The exercise was graded by properly stationed evaluators. We were fortunate that W. S. Swingler, Assistant Chief, U.S. Forest Service, Washington, D.C.; Dan Solari, District Manager, Bureau of Land Management; Lyle Smith, Fire Control Officer, Toiyabe National Forest; and Glenn Allaback, District Firewarden, Nevada Division of Forestry; were among those present to evaluate the exercise.

The exercise began at 7 a.m. when 18 men met at the Carson Airport for briefing. A preview of the exercise, including discus-

sion of techniques proposed by the pilots to accomplish its aims, took almost 2 hours. There were three pilots taking part, with each pilot allowed four drops, one on each target and a fourth at his option. The observers would go to the target area, about an hour's drive by jeep. When dispatched, the aircraft would require 10 minutes for the climb-out to the target area. At the conclusion of the last drop, the evaluators would return to the airport to gather the day's data, bringing their grading sheets for the critique. Air-to-ground communications were used extensively.

In reaching for a common understanding of the goals set by the foresters for the exercise, the pilots described limitations of the aircraft during the pre-exercise briefing. It was revealed then that three techniques were possible for making the required drop on Target Two: (1) To approach from over the ridge, (2) to make a tight turn into the cul-de-sac and out, (3) to make a high approach, staying on the target side of the hill, and a slow, descending turn to aline with the drop. The third suggestion, if workable at all, would require the dissipation of considerable excess energy without gaining airspeed. It was proposed that stalling in would do this. Of these methods, it was the consensus that the tight turn was too dangerous. A proposal for Target Three was somewhat different from the usual technique: Loft the slurry out of a steep glide, making a slow, high approach similar to the third suggestion, making the drop at the point of beginning to a roundout from the glide.

The TBM was first. Approaching Target One from the north it made a beautiful drop along the jeep trail. Two more drops on Target One followed in order, with none of the three pilots gaining an advantage. The TBM was conceded to be superior in extent of line, due to its greater load-carrying capabilities. The C-45 (as it was to perform throughout the fire season) seemed to be able to climb, get in and out, and get back on the ground faster than the TBM.

Of the three drops graded on Target Two, two were made from approaches from over the ridge and one from the descending turn discussed earlier. The approaches that crossed the ridge were made at a minimum height and minimum airspeeds, with the planes being nosed down toward the target when over the spine. In these drops, landing gear was extended and full flaps were used, with the slowing aided by using closed-engine power settings. On one of these two drops, an S turn had to be made in split seconds to line up properly when the target was visible to the pilot. All three drops were considered effective, with the TBM again showing superiority in extent of line.

The results obtained by the three pilots as flown on Target Three were quite interesting. One drop was lined up dead center on the target but the line was strung out too long; only 10 percent of the fire retardant hit the circle. Another drop, by a C-45, similarly strung out, but missing the target completely, was the only drop of the twelve that was entirely ineffective. A third drop, also from a C-45, was made at the tangent line to a pull-out arc and the entire load was laid dead on the target (fig. 1). In the

FIGURE 1.—A C-45 demonstrates one type of drop an air tanker can make: lofting the slurry—concentrating the entire load on a small area.

words of one evaluator, "there wasn't a pint wasted and the ground within a 30-foot diameter circle was soaking wet."

As for the technique of the stall approach, this way of getting into deep canyons was to be observed on several actual fires. It seemed to work well, was apparently safe, and resulted in getting in, when, with other methods, the target was out of reach.

Howard Reeder, the pilot responsible for suggesting using the stall approach, had this to say about it: "In respect to that descending-turn approach, I at first thought it might seem to be dangerous to deliberately reduce flying speeds when so heavily loaded; however, it is an effective way to lose altitude rapidly and safely when altitude control is maintained. The trick is to "mush," dissipating the energy of the high approach with "drag." Any tendency for vicious "snap" characteristics can be eliminated by

keeping the craft dropping out from under the load—you know, the way it feels in an elevator.

"In the meantime, as a side effect of that slow descending turn, the target is always in sight. At the right moment—and there is a surprising latitude of timing—you merely dump the nose and the ship is back in flying trim. Right now! In contrast to the slow and low approach over a ridge (and I've tried it) I feel this technique to be much safer. Power failure, when at 50 feet over the trees, or severe turbulence, might bring you down. In the other case, there has been no time when I could not glide-out to a reasonably safe landing—even with both engines conked."

## CONCLUSION

At the critique that concluded the exercise, pilots answered questions and ground observers reported their evaluations. All of this was condensed into a document for future study. The documentary movie of the exercise, in color and with sound, is now available on a limited basis.

The air tankers had shown a surprising facility for getting into a tight corner—the sidehill snag. In doing this, they proved their high value as an immediate dispatch tool. With an early arrival, the tanker could make a drop without delay. At the worst the tanker would be over the fire, to guide the walking crew in. The exercise was valuable in gaging the air tanker for local operations.

Good training is vital to the dependable employment of the air tanker. The tanker pilot is akin to the boxer in many respects; the better prepared and alert he is, the more successful will be his commitment when the chips are down. There is only one knockout punch in the air tanker. "Wishy-washying" into a fire attack situation can be dangerous. Good training can result in the right decisions and actions in crucial moments.

We have learned that the pilot has an ability to take care of himself in the pinches that is like the mountain goat's. We must, however, hold to the disciplines of safety and to the decision not to be wasteful. The operation must be policed for pilot proficiency, experience, and practice. We must require good maintenance and perfect air-to-ground communications. Above all, more training exercises should be required.

Incidentally, Operation Hangar Door, first scheduled for August 1, 1960, was postponed to August 10 because of the Stateline Fire on July 28. The instant commitment possible under the joint air operations agreement was instrumental in stopping this fire at 50 acres, although it had a disaster potential of thousands of acres.

By coincidence, the Division's C-45 was on a training mission preparing for Operation Hangar Door at the time of first report by Zephyr Lookout on the east shore of Lake Tahoe. With the fire location fixed only by the bearing from the lookout, the C-45 picked up the smoke, arrived over the fire in 4 minutes, scouted the access roads, and made the proper reports.

It then dropped its practice water on the fire and raced for the base at Carson Airport. In the next hour, the C-45 and the TBM

carried 2,700 gallons of borate to the head of the fire. They flew from the airport on the east side of the Sierras at an elevation of 4,709 feet, over a 9,000-foot range, to the fire at 6,900 feet on the west side. The early action prompted Assistant Ranger Norman Anderson of the Tahoe National Forest to remark, "When we moved onto the ridge with our crews, we found that the borate had held the line long enough to let us get in." Cost of the air tanker support was $1,000. Total cost of suppression was $50,000.

# AIR ATTACK COMES TO THE EAST COAST

STEPHEN C. AYRES, *Supervisory Airplane Pilot, Eastern Region, U.S. Forest Service*

A few years ago foresters noted the successful use of aircraft for delivering retardants on wildfires in the rugged slopes of the West, and speculated that such an operation would prove effective in the more moderate terrain of the Eastern States. The Eastern Region air attack program was started in late 1958 when one TBM, a navy torpedo bomber converted to carry 430 gallons of fire retardant, was acquired. After numerous air demonstrations of dropping retardants on fires before State and Federal land managers, a temporary base of operation was set up at Blacksburg, Va., on the Jefferson National Forest. An experienced airplane pilot was employed and trained for the air attack job.

The first air attack on a wildfire in Eastern Region national forests occurred during the spring fire season of 1959. This was on the Blacksburg District of the Jefferson National Forest, in western Virginia. This may also have been the first such air attack east of the Mississippi River. The tanker was also used by the North Carolina Division of Forestry on a large fire in the eastern part of that State. The tanker operated under a cooperative agreement, working out of the Coast Guard Station at Elizabeth City, N. C.

In September 1959 the air tanker dispatching and operational plan went into effect. This plan outlined the method of dispatch and control of the air tanker throughout the George Washington, Monongahela, Jefferson, and Cumberland National Forests in Virginia, West Virginia, and Kentucky, and the Southern Region of the Forest Service and the National Park Service. At the base airport, an office trailer was set up, and a dispatcher detailed to handle ground operations and dispatching. A retardant reloading base was established at Elkins, W. Va., which included one 1,600-gallon storage tank, a jet mixer, and transfer pumps. Another base is located at Weyers Cave, Va.; this base has two 1,300-gallon tanks, a jet mixer, and transfer pumps.

Air tanker operation moved permanently to the New River Valley Airport, Dublin, Va., in March 1960. Dublin Air Tanker Base has two 2,000-gallon storage trailers for both borate and bentonite fire retardant. The base has a jet mixer for borate and a circulating mixer especially designed for bentonite. Transfer pumps, hose, and a gasoline truck for refueling the air tanker are part of the equipment. Thirty tons of bentonite and ten tons of borate are in storage for immediate use.

The dispatcher's trailer is equipped with two-way radios and a telephone for communication. Forest and airway maps, plus a plotting chart, are available to pinpoint fire location when the

tanker is requested. Fire-weather forecasts are received daily, in order to predict operations.

Since tanker operation began in the East, the Forest Service TBM has taken action on 14 going fires and has dropped 17,000 gallons of retardant. Reports show that it has been very effective in stopping fire spread and assisting ground crews in control.

Tanker planes are now available through commercial contractors. At present there are five Stearman-type aircraft each capable of carrying 150 gallons (fig. 1). Other operators are showing interest in air tanker operation. In the near future planes are expected to be available for all tanker bases, if fast initial attack action becomes necessary.

Additional tanker bases are being constructed. One base is being developed at Wise, Va., to serve the southern part of the Jefferson National Forest and surrounding area. The Cumberland

FIGURE 1.—Large drop door necessary to modify Stearman agriculture airplane for fire retardant dropping. Door hinges at front with locking mechanism at rear. Most doors can be closed and locked in flight.

National Forest is developing a base at Somerset, Ky., to support ground forces in problem areas and inaccessible terrain. By spring 1961 there will be five air tanker bases strategically located to cover all of the southern forests of the Eastern Region. Contract aircraft, both fixed wing and rotor type, will augment the present air attack organization.

Heliport and helispot location surveys are being made on all national forests in the region. The locations will utilize wildlife clearings or other areas where there is high-value land or high fire risk involved. Helicopters can be used for dropping fire retardant, for air patrol, and for passenger and cargo hauling. Air patrol routes are being established for fixed-wing aircraft to supplement lookout-tower detection.

State protection agencies are beginning to show interest in this new firefighting tool. Last year, one contract Stearman and one helicopter proved highly successful in supporting a State fire organization. A water-drop amphibian plane has had limited use in another State organization. It is anticipated that more protection agencies will make use of air attack in the coming fire season.

The acceptance of air attack methods, the buildup of retardant reloading bases, and the establishment of heliports will lead to the development of a highly mobile and hard hitting air attack force capable of swift movement throughout the eastern forested areas to detect and suppress wildfires.

# FIRE COMMUNICATIONS, 1960

WILLIAM B. MORTON, *Electronic Engineer, Southwestern Region, U.S. Forest Service*

Two-way radio is no newcomer to the U.S. Forest Service. Radio networks on most national forests are in steady use to handle administrative communications of all kinds, from accounts through fire and payrolls to yucca plant reports. But the most spectacular, if not always the most frequent, use of radio is in providing communications for fire suppression activities.

It was in the field of fire suppression that radio communications had its major activity in 1960. And one of the outstanding features of radio this year was its sharply increased usage to provide communications with airborne firefighting equipment, particularly air tankers.

Air tanker drops of fire retardants have been in various stages of trial for several years. As soon as dropping retardants became a full-fledged tool, several regions recognized the requirements for radio communications with the aircraft concerned, and began to set up separate radio networks for this priority traffic. For some regions this was merely an expansion of existing networks for administration or aircraft dispatching for smokejumping.

When these networks were established, it soon became apparent that the use of aircraft for air tanker fire suppression work was no longer a local or regional affair. The trend was toward larger tankers with more range and load capacity. Air tanker operators took advantage of seasonal variations in fire suppression work by moving from one region to another, eventually covering the entire western half of the United States. But when air tankers converged on an area from widely separated points, they were then without communications, since the new area often used a different frequency.

This recognition of the interregional aspect of air tanker usage, and other problems, led to work in 1959 and early 1960 to establish common air net radio frequencies in the high VHF band for all regions west of the Mississippi, and a policy for interregional use of air tankers. Specifications were drawn up for procurement of air tanker radios, and radio networks were established or expanded or modified to fit.

It was almost as if this work had anticipated the 1960 fire season. Serious project fire situations in nearly all western regions called for interregional use of air tanker radios as never before. But even with the work done early in the season, some regions were unable to meet the increased demands for air net communication. Shortages of radio equipment, either fixed stations for air net control points such as new air tanker bases, portable equipment for ground-to-air communications, or aircraft type for tankers, required emergency procurement. Electronic

technicians as well as air tankers were shuttled from region to region to meet increased demands for radio installation and maintenance during the emergency. Before the fire season ended, emergency demands severely tested an air net radio system which was only partially prepared at the start of the season. It met the test quite well, considering all.

The fire season ended with experience-bought plans to build up the necessary air net radio systems. Some network systems were changed; some equipment weaknesses developed, but in general the direction taken in 1959 remained as established.

The air net radio system probably would not have done as well if it had not been able to fall back on an existing, well-established communications organization. This organization has worked for years along general guidelines: (1) to obtain the best possible radio equipment, (2) to install that equipment in a system designed to best meet the need, and (3) to maintain equipment to high standards of performance by the electronic technician organization.

Radios are purchased under specifications designed for a planned radio system. Basic communications system design is done by regional electronic engineers. Existing forest radio networks are integrated with telephone systems to meet administrative needs. New systems such as air net are planned around the needs according to basic communications engineering principles. An example is the trend to high band (170 mc) systems because of periodic sunspot-caused interference on older low band (30-40 mc) systems. Long-range planning sometimes includes radioteletype network possibilities.

The backbone of the communications organization, however, is the electronic technician at the national-forest level. He installs and maintains the radios according to standards set at regional and national levels. He makes experience-born recommendations for system improvements. He tests new equipment as received from the factory for compliance with specifications. All this requires organizational work at regional and national levels such as revision of specifications, recruitment and training of competent technicians, and providing adequate test equipment with which to meet the standards.

These standards are in many cases higher than those set by industry in general, probably because of more exacting requirements of Forest Service communications. This, in turn, requires greater emphasis on training procedures, and in some cases developing new test techniques.

# COOPERATIVE FIRE PROTECTION IN THE BLACK HILLS OF SOUTH DAKOTA

Kenneth Scholz and Jack McBride[1]

The Black Hills in South Dakota and Wyoming, the only area of compact timbered mountainous terrain in the western Great Plains, is entirely surrounded by flat treeless prairies. Nearly all of this area is in South Dakota and is included in the Black Hills Fire Protective District. The district's approximately 2½ million acres of ponderosa pine forest are protected from fire by cooperative agreement between the South Dakota Department of Game, Fish, and Parks and the U.S. Forest Service, National Park Service, and U.S. Bureau of Land Management.

The district is crossed by routes U.S. 14 and U.S. 16 from east to west and by U.S. 85 and U.S. 385 from north to south. Most of the forested area can be reached by road.

Recreation use during the summer months is heavy. The Black Hills National Forest ranks sixth in recreation use among the 152 national forests; in 1960, 2,695,000 visitors were recorded. The National Park System in the Black Hills—Mount Rushmore National Monument, Wind Cave, and Jewel Cave—recorded over 1,900,000 visitors. Custer State Park, one of the largest state parks in the Nation, recorded 850,000 visitors. An estimated 3,000,000 additional people use the various highways for purposes other than recreation.

Fire occurrence is heavy and spread rather evenly throughout the year. Because of this, permits are always required for open fires. During the past 10 years there has been an average of 225 forest fires per year.

The district is susceptible to periodic occurrence of large disastrous fires. The larger burns are so severe that in many instances reforestation has been a serious problem. Because of more intensive fire protection and increased timber harvest, there has been a substantial increase in the acreage of dense ponderosa pine reproduction. With the hazard of crown fires in these young stands, larger acreage of more destructive burns may be expected.

The average annual precipitation in the area varies from less than 17 inches in the south to 28 inches in northern hills, with about 65 percent falling from May to September. February is usually the driest month. Many of the frequent thunderstorms of June, July, and August are without measurable moisture. Multiple fire ignitions are common.

---

[1] Fire Control Officer, Black Hills National Forest, and Fire Control Forester, South Dakota Department of Game, Fish, and Parks, respectively.

With this fire situation, only a well-planned and coordinated fire control organization can provide the resource protection necessary for effective land-management practices.

Seeking such an organization, the men responsible for the management of these wildland resources wrote a fire cooperative agreement in 1945. The agreement was aimed at integrating and using most efficiently the fire control forces available in the area. With some modification, it has been in effect ever since.

The effectiveness of the cooperative effort was illustrated on August 22, 1960. With humidity less than 10 percent and temperatures 90 plus, fire dangers were extreme. A severe lightning storm started 28 forest fires. At least 12 were handled by local fire departments without Federal or State supervision. All had the same potential as the 3 that reached project size that day. The largest, a wild one, burned 10,000 acres from August 22 to 26.

These 3 project fires and 25 class ABC fires put the control facilities of all the cooperating agencies to a severe test. The Game, Fish, and Parks Department called in men from all over the State. The Forest Service called overhead from Wyoming, Colorado, Montana, and Nebraska. The Park Service and other Interior Department agencies made available nearly all their manpower and equipment.

The largest fire was handled cooperatively by the State and the Forest Service. The fireline was split into two divisions. The State provided overhead for the day and night shift on one; the Forest Service did the same on the other. Personnel from both units made up the headquarters. Communications were handled by the Game, Fish, and Parks Department on its radio network.

While cooperation on project fires is a valuable part of the agreement, there are other benefits. The State Forester has agreements with the boards of county commissioners of the six counties in the fire protection district. The counties receive financial and material aid under the C-M2 program.

The State Forester has carried out an aggressive program of acquiring and using military-surplus equipment. He donates it to the various counties for assignment to local fire departments for their use in fighting forest fires. This program has improved the speed and efficiency of initial attack and, probably equally important, has contributed much to the morale of the departments.

In the fire protective district are 26 organized volunteer departments that participate in this program. Under the program, these units have received 20 jeeps, 3 small tankers (pickups and small trucks), 14 large tankers, 4 jeep trailers, 5 complete rural fire trucks, and many other items. Direct purchase of equipment by State, County, and local fire departments has helped to round out each unit's equipment supply.

Each of the cooperating agencies except the Bureau of Land Management maintains a complete and up-to-date fire control organization of its own. The addition of the C-M2 units to the local fire departments makes it much easier to provide the supplies and equipment necessary for extraordinary fire situations.

Some problems have developed. Each agency maintains its own radio network and sometimes communications are a problem. To ease this situation, one State lookout, one national-forest lookout, and the national-forest dispatcher maintain a cross-monitoring system. These three have been able to provide the necessary cross-channel communication for the routine fire load. Additional cross-monitoring stations are set up if the need arises.

At least once each year all agencies meet to review the agreement and to work out methods by which the cooperation can be improved. Several districtwide training sessions are held each year.

Residents of the Black Hills are fire conscious. In an area where wildfire is a threat, this is understandable. It is one of the basic reasons why cooperative fire protection has been an outstanding success.

# EVIDENCE IN FIRE TRESPASS CASES

JOSEPH COUCH, JR., *Forester, Division of Fire Control, Southern Region, U.S. Forest Service*

Comparisons of successful fire trespass cases often reveal that their beginnings were marked with a common factor: some initial bit of information on which to start. The hard fact, established by the experience of many investigators, is that the officer who opens a case with nothing to go on but a big area of blackened timber is working against long odds. Some professional investigators avoid such cases whenever possible—an understandable course if they feel compelled to maintain a high percentage of "hits."

Even unfavorable odds do not necessarily make fire investigations a poor investment. The values involved often make the cost of the most thorough investigations negligible by comparison; the money spent can bring important returns. For example, persons damaged by the negligent acts of others are entitled to be "made whole." Investigation serves as the foundation both for civil suits to recover damages and costs, and for criminal cases, in which the immediate objective is conviction of the offender. In *all* cases the ultimate prize is the prevention of future fires; whether or not damages are recovered or a conviction is obtained, a bulldogged investigation has a powerful prevention effect.

Neglect of law enforcement in favor of all-out suppression is sometimes justified with the argument that suppression is "an emergency," while the investigation "can wait." The emergency is conceded, but can we be satisfied with practices which fail to improve the situation? Sooner or later we must come to grips with the law-enforcement job to help carve the fire load down to size.

The investigating officer seeks to discover answers to the key questions, "Who, what, when, where, why, and how" regarding each violation, and to present the evidence so that a judge and jury can see and hear for themselves those things which make the story clear. In general, any object found at the scene which cannot be explained except with reference to the offense should be treated as evidence. The proof may be entirely circumstantial; while direct evidence is generally preferred, circumstances, in a chain well developed and linked together, can swing the balance.

The old fire chief's axiom, "The first 5 minutes are worth more than the next 2 hours," could have been said by an investigator. Delay is a bugbear to all fire personnel; it can multiply suppression problems, but it can completely destroy the investigator's case. It is disappointing to arrive at the fire's point of origin only to find that a bulldozer got there first. The fire's spread, falling of burned vegetation, work of heavy equipment, and movements of firefighters are quick to destroy physical evidence. Therefore, the

foundation of the law-enforcement phase of the fire job—investigation—must come before, or at least with, suppression.

In high-occurrence areas, law-enforcement specialists are spread thinly. Usually, the initiation of a fire investigation is in the hands of the first-attack foreman. Many successful cases can be credited to a first-attack man who got to a fire with so little delay that he was able to observe a departing suspect or record his license number, rope off the point of origin, preserve a clear footprint or tire track, save the smouldering remains of an incendiary device, or clamp onto some other evanescent clue before it could vanish in smoke or churned-up soil.

Men who are required to collect evidence must know what to look for—and how to care for it. Selected individuals should be given specialized training in investigative work. *All* fire-going people need to be trained to observe significant events and to protect evidence.

Investigators should carry a kit containing—as a minimum—a photographic outfit; plaster outfit; cartons, pillboxes, bags, and envelopes; notebook, pencil and ballpoint pen; and a steel tape. When fire seasons are favorable and the kit goes unused for a time, the investigator should resist the temptation to leave it at the office. Like a snake-bite kit, when it's needed, it's *needed*!

The notebook and pencil are essential. Good investigators develop expertness in taking notes, making a detailed record of everything observed and done, with date and time entries, names, places, objects found, and sketches with measurements. Good notes are the backbone of the case. Cross-checking of the statements of witnesses and suspects, discovery of gaps in the case, completion of leads, preparation of the report, recall of details on the witness stand—all will require frequent reference to the notes. Businesslike documentation of the investigation helps develop a supportable case and makes the investigator a confident, impressive witness in court.

Fire investigators should have experience in taking photographs. With a little instruction, reading, and a generous amount of practice, any officer can produce clear pictures. In this work, challenging problems are the rule because of such situations as dim lighting or even darkness, poor contrast such as a charred object on blackened ground cover, or minute detail such as a nick in a horse track. Many investigators develop their own films, and make their prints, or use a Polaroid camera, to simplify on the witness stand the story of the photographs' handling and "unretouched" character. Juries can seldom visit crime scenes. Photographs of the general area, of important spots such as the point of origin, and of closeups of the evidence in place, will help jurors gain understanding. They also help the investigator in a pretrial review of the case.

The value of dental plaster of paris in making impressions of evidence is well known. Plaster-cast exhibits are ideal for court use. Suspects confronted with them sometimes admit their responsibility.

The nature of evidence is such that no allowance can be made for doubt. This dictates great care in handling, marking for future

identification, and protecting from contamination or loss. Scientific examinations by laboratory experts can identify the sources of many items such as paint particles and tool marks. Careless handling may hinder the examination, or even destroy the value of the items as evidence.

The chain of possession of evidence must be complete. Ideally, a single witness would be able to testify that he personally found, marked for identification, kept in possession under lock and key, and is now handing to the court, the object of evidence under discussion. If possession must be transferred to others, as when evidence is mailed for laboratory examination, each change of hands should be covered by a signed receipt. The integrity of each item of evidence must be kept absolute.

On most investigations the major portion of time is spent interviewing witnesses and suspects. Obtaining information, especially from hostile witnesses and suspects, is seldom easy. It can be facilitated, however, by interviewing each person at the earliest possible moment, getting his testimony down on paper and having him sign the statement. This tends to prevent forgetting and the alteration of testimony.

Investigators should work with a partner, if possible. The second man is valuable as a witness, assistant, and if need be, an alternate.

Sheriffs or other professional police officers can be very helpful for the more specialized phases of criminal investigation. Close working relationships and understanding should be developed with these men and their advice and assistance sought when needed.

## SUMMARY

Fire investigations pay off in their effect on fire prevention and often in damages recovered. Men responsible for investigations should be trained and equipped to locate and preserve evidence. All firefighting personnel should assist by being observant and by protecting points of origin. Delay is the investigator's principal enemy; work should begin before or with suppression. Detailed notes and sketches are the backbone of the case. Evidence must be carefully handled. All witnesses and suspects should be interviewed as early as possible and their testimony recorded in signed statements.

# CAMP HALE FIRE COOPERATIVE CONTROL

JOHN P. BURKE, *Forest Ranger, Holy Cross District, White River National Forest*

The Camp Hale Fire started within the White River National Forest in Colorado on June 26, 1960. It was declared out on July 11. The combination of problems in this fire probably was without precedent. The fire started from operations of a military-research project on an area that was closed to all nonproject personnel—Army, Forest Service, and civilian—except for specified periods when neither security nor operations of the project would be interfered with. Without a fully coordinated effort by personnel of the U.S. Army, U.S. Forest Service, and the special project, it is likely that the fire would have escaped control and endangered personnel.

Contact with the Camp Hale Fire Department was made just after noon, June 27. It was believed that only test materials were being burned; the fire was reported to be very small and under control. Inspection by nonproject personnel at the time was impossible for security reasons.

Later that afternoon strong winds caused the fire to spread out of control, threatening a large area of timber and high-value watershed. The fire burned an area being used by the project as a weapons-impact area, known to contain duds—unexploded artillery shells. The burn was uneven and spotted over the area, which is rough and steep, marked with cliffs and talus slopes.

First control efforts, during the afternoon and evening of June 27, were by ground forces, thoroughly briefed on the hazards of topography and explosives. They worked to cold trail the outer perimeter and connect salient points. We then learned that the fire covered part of a larger impact area used by the Tenth Mountain Division in 1943 and 1944. The old duds were as dangerous as ever.

We attempted to locate a control line behind dud-free topographic barriers that would shield the ground from artillery fire. We continued on this basis for a day and a half. Then we learned that the artillery firing had included mortar firing, and all attempts to control the fire by usual ground methods were suspended. It was now evident that, except for a short stretch on the main fire and on one isolated spot, there was no safe place to locate the control line. Aerial control methods had to be employed.

Military research project activities were suspended in the immediate vicinity of the fire. But ground access to the fire was through the project area that was still active. Although the area could be cleared occasionally for nonproject travel, it was closed most of the time. Since six-place military helicopters were available, much of the early access to the base of the fire was by helicopter. It also was expedient to use the helicopters for reconnais-

sance, though the fire area was generally visible from a nearby restricted road.

Two of these helicopters continued to serve for reconnaissance and limited transportation. In addition they transported more than 100 men from base camp at 9,700 feet elevation to a helispot above timberline at 12,000 feet. From there the men walked down to the fireline, arriving fresh and alert. This operation was repeated the following day.

Two military helicopters, two civilian helicopters, and one civilian monoplane were employed to drop bentonite slurry. The helicopters were employed also for limited transportation as well as for considerable scouting to evaluate and plan slurry drops. In 403 drops, they delivered 19,955 gallons of slurry (figs. 1 and 2).

No ground-control forces were employed in the slurry-dropping stage except on one spot fire, which was isolated from both the main fire and the contaminated area. Even here two well-placed slurry drops held the fire from crossing to new fuel until ground crews could arrive. In the more than 30 minutes gained by these slurry drops it was possible to contain the spot fire within safe ground.

Final mopup of the few remaining smokes was done by project men, trained in detecting and handling duds, who were trained by the Forest Service in mopup. They were supplied wet water in backpack pumps lowered by rope from a helicopter.

In this fire the accident potential was unusually high because of the following problems:

1. The firefighters were soldiers, unfamiliar with either forest fires or mountainous terrain. There were as many as 150 soldiers employed at one time on several occasions.
2. The terrain is rough and precipitous—a hazard to ground and air operations.

FIGURE 1.—Helicopter with loaded 35-gallon slurry bag.

FIGURE 2.—Helicopter over slurry-loading pit.

3. In helicopter operations, especially in hauling personnel, loading slurry, and closely controlling slurry drops, there are inherent dangers.
4. Air traffic was heavy, with four helicopters and one monoplane dropping slurry in a limited area at the mouth of a canyon.
5. The fire area and surroundings were generally contaminated with unexploded artillery shells. Four of these duds were detonated by the fire during control operations.
6. Artillery was fired intermittently across the direct line between slurry-mixing depots and the fire.

These problems were met in the following ways:

1. Forest Service overhead, briefed regarding these hazards, maintained communication by portable radio. They assumed responsibility for the safety of their men.
2. Adequate headlamps were provided for a select crew the first night. Only daylight operations were conducted thereafter. Pilots were constantly consulted regarding the limitations of their aircraft and the dangers. One man, struck on the side by a falling rock, was sent to the doctor, with no disability or lost time. There were no other injuries.
3. The best possible landing spots were selected. Pilots were repeatedly consulted. We constantly reminded them that we depended on their judgment regarding aircraft safety. To get working space during loading operations helicopters were set down over pits and their motor speed was reduced.
4. Flight patterns of all aircraft were made known to pilots insofar as possible. A separate target area was assigned to the monoplane, and its time of departure and progress were given to all pilots either by radio or word of mouth.

A separate airstrip, with mixing station, also was assigned to it. Departures were delayed as necessary.

5. Plans of operation for ground control were changed, regardless of inconvenience or cost, when it was determined that an area might be contaminated with duds.
6. Close, continuous liaison was maintained between U.S. Forest Service personnel and the commanding officer of Camp Hale, who handled liaison with project personnel.

Slurry operations were not expected to extinguish deep-seated fires, though effort was made to get decisive results. Their purpose was to contain the fire and allow it to burn out and die out until mopup was reduced to the minimum.

Fuels varied from open hillsides with sparse grass cover and occasional decayed windfalls to heavy, full-crowned mature spruce and fir stands with many decayed windfalls.

The monoplane was effective in checking and preventing spread in sparse fuels in the less difficult target area. The necessary flying speed broke the slurry into a fine spray and some was lost in drifting mist. This plane made quicker trips and delivered larger loads, covering more ground than the helicopters. It was effective in the area assigned.

The helicopters made concentrated drops with excellent accuracy in the difficult target areas over sharp ridges, near cliffs and bluffs. These were areas of heavier fuels, and fire spread was effectively checked in spite of occasional flareups and spotting. The principal spot fire threatened to spread out of control into dud territory, but spread was promptly stopped by two precision drops made while a ground crew was being dispatched.

Slurry and wet water drops for 5 days wore the fire down to a few small smokes. The special mopup crew reported a 13-inch cover of bentonite slurry under timber in a particularly troublesome area of stumps and windfalls, some of which were still smouldering.

The slurry operation accomplished all that was expected of it, though it consumed much time and the cost was high. It contained the fire and reduced to the minimum the exposure of men to explosions of duds.

New problems for which we had no precedent—continually arose. Only one temporary partial injury occurred. Errors made were largely offset by the alert safety consciousness of nearly everyone connected with the fire. Cooperation by the pilots, Camp Hale, the project, and Forest Service officers contributed to a good safety record under very hazardous conditions.

## FIRE RAKE SHIELD

LLOYD E. MYERS, *Fire Warden, Division of Forestry, Ohio Department of Natural Resources*

This shield covers the sharp teeth of the fire rake to protect other tools carried in tool boxes or on fire trucks. It can be made from discarded auto license plates 6 by 12 inches, or the plates can be cut to this size. Sheet metal, 18-gage, may be used.

Bend the metal to make a 3- by 12-inch piece with the letters turned out and the slot between less than the thickness of a rake tooth (fig. 1).

FIGURE 1.—Fire rake shields in use.

To put shield on rake, line up on teeth and strike rake lightly on the ground with the teeth down. Shield will slip tightly over rake. To take shield off, strike rake handle lightly near its eye over a stump or other object. Shield will fly off.

If shield gets bent or is too loose, put it on a flat surface, step on it, and it is ready for reuse.

# THE WALLOWA-WHITMAN STORY—1960

O. B. CARY, *Fire Control Staff Officer,* and JOHN B. SMITH, *Forest Supervisor, Wallowa-Whitman National Forest*

In 1960 the Wallowa-Whitman National Forest had its most disastrous fire year since 1910 and perhaps the most disastrous fire year since the forest was established. With good fire organization and improved facilities for fire suppression, why did this occur? Here is the story.

The Wallowa-Whitman includes an area of 2.36 million acres, of which 2.22 million are national-forest land. It is located in the Blue Mountains and Wallowa Mountains of northeastern Oregon. Elevations range from about 900 feet on Snake River to 10,000 feet in the Wallowa Mountains. Included is some of the roughest topography in North America in what is known as Hell's Canyon of the Snake River. Precipitation varies from 10 inches on the southeastern part of the forest to 40 or 50 inches in the higher elevations.

Cover types include cheatgrass and bunchgrass, brush, slash, ponderosa pine, mixed Douglas fir-true fir, lodgepole, and some alpine species. Commercial timber stands range up to 40 M board feet per acre in the mixed types.

The Wallowa-Whitman is one of the heavy fire forests in the Pacific Northwest Region. It has an average of about 100 lightning fires and 25 to 50 man-caused fires annually. A long summer period of severe fire weather is normal, but some years are much more severe than others. The daily burning index, on a scale of 100, averages about 25 to 30 in July, and 35 to 40 in August, with the daily index occasionally reaching 75 or higher.

The 1960 fire season was longer than usual. March, April, and early May were warm, resulting in heavy vegetative growth. The latter part of May, June, and July were dry, making a long period without significant precipitation. Measured fire danger for all of eastern Oregon was the most severe since 1931.

Forest officers recognized that the situation was very dangerous. On July 17, farm workers started a fire which ran away. It was readily accessible to firefighters, machinery, and aerial attack. Control action was fast, but it burned 140 acres in easy topography before being controlled.

Between July 9 and July 24, the burning index from a fairly representative lookout (Bald Mountain) ranged from 77 to 90, with only 3 days registering lower values. Fuel sticks measured 4 percent moisture content most of the time with little or no night recovery. On July 19, the burning index was 90 (fig. 1) and fuel sticks were 4.

The Supervisor's office in Baker, Oreg., had 104 degree temperature on July 19. This set a high temperature record unequalled

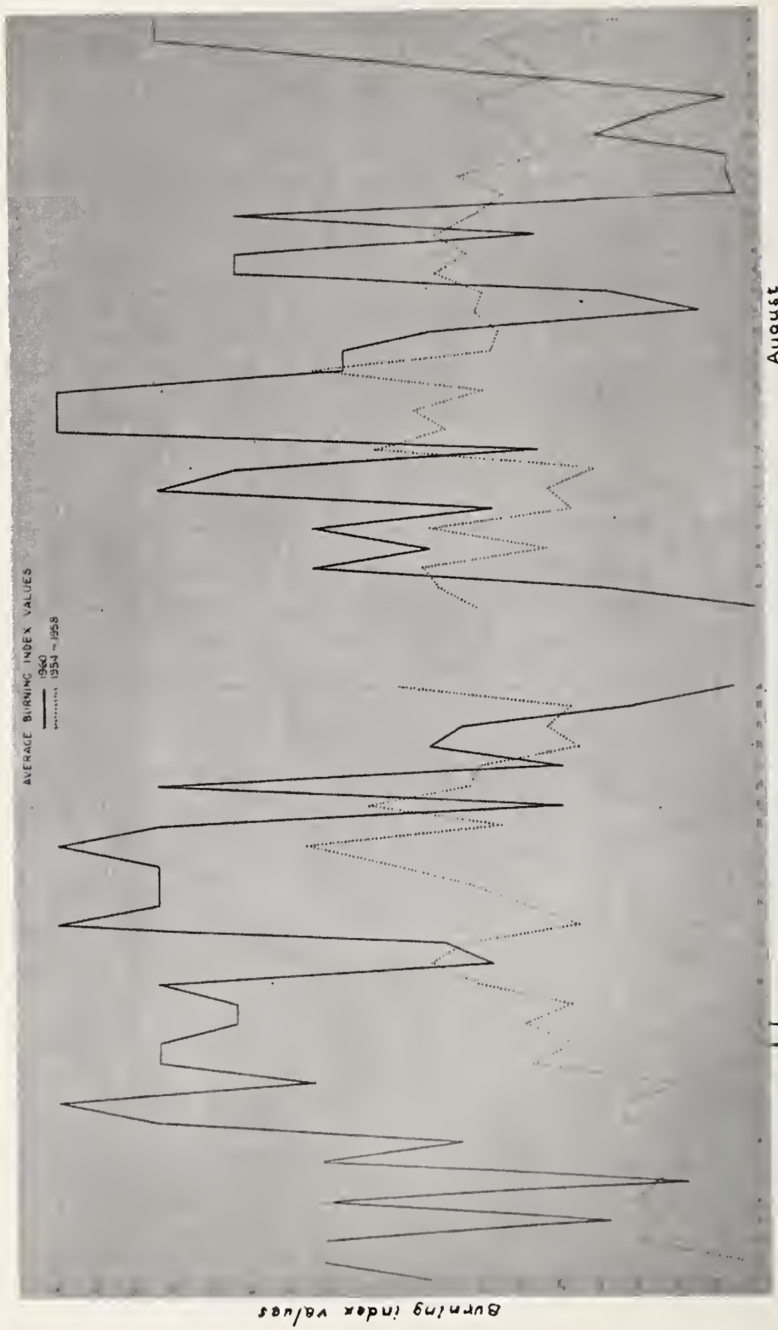



FIGURE 1.—Burning index values for July and August 1960 and average values 1954-1958 for Bald Mountain Lookout, Wallowa-Whitman National Forest.

in the past 70 years. A 40 percent chance of lightning was forecast the morning of July 19. By midafternoon, local observation indicated that a lightning storm was likely to occur. Normal forest work was stopped and all forest resources were readied for a severe fire situation.

Lightning started on the south end of the forest at 6:30 p.m. The storms moved northerly and northeasterly across the forest and the last lightning activity was reported about 9:30 p.m. No rain fell and fuel moisture recovery was only slight. More than 135 fires started and some spread rapidly. A few fires in light fuel types and rough topography had covered more than 600 acres by early morning of July 20. Logging and mill crews, construction crews, and all other available local manpower and equipment were recruited and quickly dispatched. Cooperation of the local lumber companies and individuals was excellent. Dispatching continued through the night. More than 700 firefighters and overhead were on fires or in the near vicinity enroute to fires by daylight. In addition, more than 25 bulldozers and numerous ground tankers were being used.

Aerial operations started at daylight July 20. Smokejumping and air tanker operations started simultaneously. By noon 45 jumpers had parachuted to 16 fires. By evening, a total of 69 smokejumpers were placed on fires, 24 of them on fires in the nearby Malheur and Umatilla National Forests. Air tanker operations started at daylight with three B-25's, one PV-2, and one PBY. By evening, one additional B-25 had arrived. Approximately 50,000 gallons of borate were used that day. Drops were made on small fires and on fast-spreading fire perimeters. Aerial observation and cargo dropping continued throughout the day.

One helicopter was used throughout the day. Additional helicopters could not be obtained because of major forest fires in many other parts of the West.

Most fires were under control by 10:00 a.m., July 20. That evening, 24 hours after the lightning storm started, there were 7 Class D and E fires burning. Several additional fires were in no better than a "corralled" status. Five smaller fires combined to form the large Anthony Fire which had covered about 7,500 acres of timbered lands and was spreading rapidly (fig. 2).

The North Fork of Burnt River Fire had covered 2,000 acres and was burning in grass and timber. The Cactus Mountain Fire (1,000 acres) and the Cow Creek Fire (1,000 acres) were burning in grass and timber in very difficult topography in the Lower Snake River Canyon. The Chesnimnus District had five Class C fires which were giving trouble. A 10,000-acre fire burning north of the forest boundary was a threat. The Imnaha-Snake District had the Waterspout Fire (700 acres) and the Pony Creek Fire (2,000 acres) which were difficult to control because of very rough topography. The Pine District had the Spring Creek Fire (2,500 acres) in the rugged Snake River Canyon.

Additional recruiting of overhead, manpower, and equipment was being carried on throughout the Pacific Northwest, and dispatching was prompt.

By July 24, reportable fires from the July 19 storm stood at 118. There were, or had been, 10 Class E, 4 Class D, and 4 Class C fires. Maximum buildup in manpower was reached on July 24 with 4,700 men, of which 800 were Forest Service overhead and organized Forest Service crews. The number of men decreased to 1,700 by July 29, and systematically diminished as the fires permitted release. There were 56 bulldozers, 25 ground tankers, 30 portable pumps, 80 power saws, 11 helicopters, 18 air tankers, and 20 other aircraft in use during this fire period. Three hundred and sixty-eight thousand gallons of borate were dropped.

Early in this emergency period, two staging areas, one at La Grande and one at Baker, were established. These two cities are transportation centers, and with the numerous fires forestwide, it was not known where men would be needed next. Manpower was brought into these staging depots, supplied with overhead, organized into crews, and then dispatched to where they were needed. In the staging areas the men were messed, rested, and controlled. Off-duty police in uniform were used to keep order and prevent the men from scattering. This system worked well, and few problems developed between townspeople and firefighters.

Other severe lightning storms occurred on July 26 and on August 9. The last major storm of the year, on September 11, set 29 fires. Fire occurrence for 1960 was as follows:

| *Period* | *Lightning fires (number)* | *Man-caused fires (number)* | *Area burned (acres)* |
|---|---|---|---|
| Prior to July 19 | 48 | 20 | 221 |
| July 19-25 | 118 | | 45,886 |
| July 26-August 8 | 40 | | 234 |
| August 9-September 10 | 21 | 18 | 2,710 |
| September 11-October 31 | 29 | 35 | 962 |
| Total | 256 | 73 | [1] 50,013 |

[1] Man-caused fires burned 1,184 acres.

To sum up, the Wallowa-Whitman had the most disastrous fire year of record. Fire weather was very severe and fire occurrence the highest of any year on record. The total was *329* statistical fires: 14 Class E, 7 Class D, 12 Class C, 75 Class B, and 221 Class A. Only 19 were extraperiod fires and uncontrolled within the first work period.

Extreme fire weather and extremely heavy fire occurrence seldom occur in combination to the extent they did on July 19. It was far beyond the capability of the forest's initial attack forces. A substantial buildup in forces was made to meet the threat of an extreme fire situation, but management did not foresee the abnormal numbers of fires that would start, or their wide distribution over the forest. While the storm was still in progress, local sources of manpower and equipment were called, and they responded well.

If disastrous losses are to be prevented during abnormal fire years, a complete review and revision of our fire control resources and facilities is necessary. One serious handicap was lack of helicopters. More smokejumpers would have been helpful in the early

FIGURE 2.—Anthony Fire in head of Anthony Creek. Anthony Lake in foreground.

stages. There were not nearly enough radios to provide the communication needed.

More highly skilled fire specialists were needed as were more trained crews. Twelve Forest Service crews were used on these fires. Their performance was good to excellent.

The disastrous losses which occurred in 1960 must not be allowed to occur again. The fire organization must be strengthened locally, and a strong flexible force must be available to back up the local organization when this "one in 50 years" occurs.

# TRACTOR TANKS—DEVELOPMENT AND USE IN WISCONSIN

William Meharg, *Assistant Chief Forest Ranger, Wisconsin Conservation Department*

The development of water tanks on fire suppression crawler tractors in Wisconsin has been a lengthy process. It has added to the versatility of the fireline tractor-plow unit. Its value has been accepted by fire control forces and now all primary fire suppression tractors are equipped with tanks and pumps. Annual replacements of old-model tractors have tank installations as a part of the modification required to keep approximately 70 fire suppression tractors immediately available for use (fig. 1).

When tractor-plow units of a size adequate for fire suppression and in a weight class to be easily transported became readily available, they soon were an integral part of our initial attack effort on nearly all surface fires (fig. 2). As their use broadened and more power and speed became standard in newer models, an increase in the disparity between line constructed and line held


Figure 1.—New tractors, after modification, ready for distribution.

FIGURE 2.—Tractor-plow unit in use on fire, plowing and pumping water.

became more evident. The success of the units during severe burning conditions decreased somewhat partly as a result of the change in forest cover and partly because of expanded use in direct attack effort.

To increase the efficiency of tractor-plow units, water tanks were saddle-mounted directly over the tractor tracks. Over a considerable period of time, numerous adaptations were made and used. As an aid in controlling surface fires, their value soon became recognized, and more recently the installations have become standard (fig. 3). The capability of carrying and pumping water for use in critical situations has contributed to our ability to control approximately 90 percent of the fires to less than 10 acres burned.

The standard mounting now used is two tanks, each about 75-gallon capacity, connected together with a 1½-inch flexible line coupled to a flange-mounted pump driven by a rear power take-off. Operator guards and modifications to permit access to the tractor engine complete the installation.

On the fire, the tractor operator uses the pump at his discretion and handles the hose and nozzle. He determines when water use is necessary for control of the fire and with the capability of plowing and pumping simultaneously can determine how best and where to attempt control.

Any water source available to the tractor can be used to refill the tanks directly through the power take-off pump. Under cer-

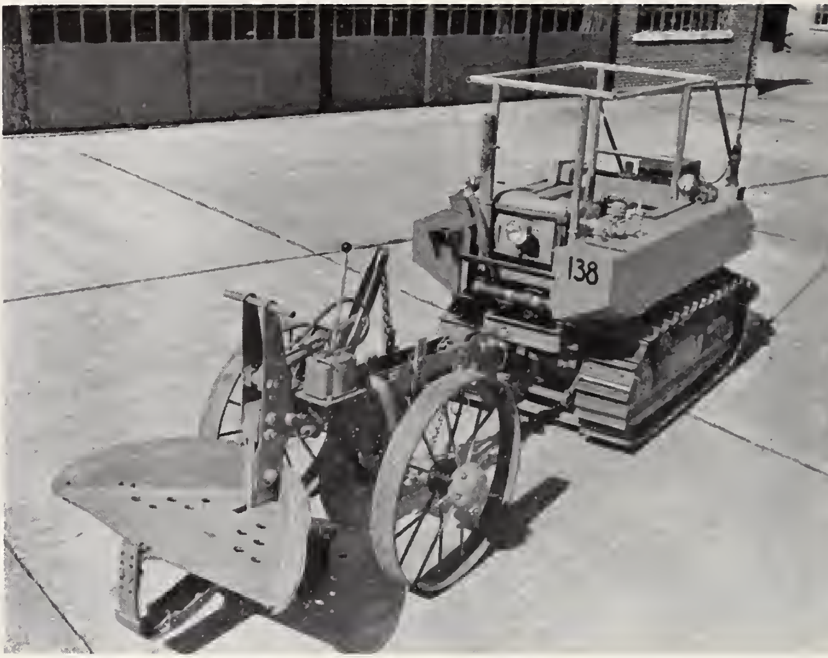



FIGURE 3.—Conventional tractor-plow unit.

tain conditions, we have found it practical to use a 250-gallon tank trailer instead of a plow and depend on the combined water supply to control the fire. Another attack combination is one tractor with tanks pulling a water trailer tanker, working directly ahead of a tractor-plow unit. This combination has been very successful on the severely burning flanks of a surface fire.

The tanks when full add about 1,500 pounds to the tractor weight and usually improve traction. The tanks also afford a measure of protection to the tractor operator. The obvious disadvantages are the added weight on soft ground and some little loss of stability. As a result of years of experience under many conditions, we believe the tractor tanks to be an asset and expect to continue this type of installation.

# PORTABLE PUMPS FOR MORE EFFECTIVE CONTROL

L. J. McDonald, *Superintendent, Ely Service Center, Superior National Forest*

In the early days of forest fire control in the North Central Region, the use of water was secondary to hand line construction. The water quite often was available but the means of applying it efficiently were not. Power pumps and hose were too heavy and cumbersome, breakdowns too frequent, and trained crews nonexistent. Today, in the North Central Region, and especially in its northern forests, water is generally in abundant supply and more often than not is depended upon for initial attack.

Throughout the years gasoline-driven, portable firefighting pumps have been greatly improved. Good construction and simple, reliable operation is now the rule. Weight has been reduced from well over 100 pounds to 35 to 75 pounds. Many of the pumps are capable of pressures up to 200 pounds and will deliver from 20 to 50 gallons per minute at 150 pounds pressure, depending upon make and model.

Hose improvement has kept pace with the manufacture of lighter, more durable, and trouble-free power pumps. Lightweight linen hose and plastic-lined hose in the 1-inch and 1½-inch sizes, capable of withstanding high pressures, are now available.

The accessories are as important as the power pump and hose. Here, too, much progress has been made with nozzles, valves, bleeders, and other accessories, to obtain precision and lighter weight. In addition, light-weight reservoir tanks of canvas and neoprene rubber, which can be quickly erected, have been developed for relaying water.

Improvements in laying hose to reduce or eliminate wrestling with heavy, cumbersome rolls and packsacks are being steadily made (fig. 1). The aim of all these improvements is to enable attack crews to use fewer precious minutes and thereby keep the perimeter of any fire to a minimum.

Because of these improvements and the action of well-trained "hot-shot" crews, the use of water is no longer secondary to other means for initial attack. Direct attack is not always possible with handtools alone. Water, quickly and properly applied, cools down the front, making direct attack possible. The judicious use of water enables a crew to secure much more rapid control and to hold greater lengths of line per man, more quickly and with less fatigue than before. The end result is smaller area burned and lower suppression cost.

At one time it was deemed advisable to have a one-size portable power pump that would meet all fire needs. Standard accessories would also be the rule. Such a development has not occurred

FIGURE 1.—"Hot-shot" crewmen practicing hose laying.

through the years and it is doubtful if it will now materialize. On the Superior National Forest it has been found that various size pumps and capacities are needed to meet the requirements of modern transportation, accessibility, and fast attack.

Weight of pump, hose, and accessories is very important to initial attack in the Boundary Waters Canoe Area of the Superior, where access is by seaplane or boat, canoe and portage. Whenever the burning index is 13 plus, a light-weight pump is carried in each of the two DeHavilland Beaver seaplanes. Pumps in the 35- to 40-pound weight class, with light-weight 1-inch linen hose and accessories, are a must. Pressures developed and the gallons per minute produced by a pump of this size are adequate in most instances, especially when attack is quick and fire perimeters small. When burning indexes are 25 plus, "hot-shot" pumper crews of three men accompany the pilots. When a forest fire is spotted, the seaplane lands at the closest lake and the crew takes off from there.

Heavier pumps of medium size or approximately 75 pounds weight, with increased pressure and more gallons per minute, are required for followup where speed of attack is no longer a factor but greater amounts of water are necessary. These pumps should also be used where they can be transported close to the fire and a water supply (fig. 2).

The large centrifugal pumps capable of producing 300 to 500 gallons per minute and mounted on two-wheel trailers, also have their place in fire suppression. These are used on large project fires where they can be pulled by truck or tractor direct to the source of water. They are usually powered by four-cylinder, gas-operated motors.

FIGURE 2.—Medium size pump and accessories, including 1½-inch linen hose.

Taking all of the above into consideration, the fire manager decides which pump to use: small, medium, or large. If initial attack fails, all three types of pump might possibly be found where a road system to the fire is available.

On the Superior National Forest, our newest tactical weapon in the use of water in fire suppression is the streamlined 125-gallon water tank mounted under the belly and between the floats of the DeHavilland Beaver seaplanes. As the seaplane taxis along the surface of a lake, water is forced into the tank through a pickup tube in the short period of 13-15 seconds. Quickly airborne, the plane proceeds to the fire and drops the load of water where it will do the most good. Quite often this is being done before the "hot-shot" crew arrives on the fire. Water dropping from the seaplane is not an attempt to extinguish the fire but only a holding action until the ground crew can take control.

Additional pumps, hose, gasoline, and tools, as needed by the ground forces, can be quickly dropped from the pontoons of the seaplanes.

# JEEP WATER UNITS FOR FOREST FIRE SUPPRESSION IN MISSOURI

JERRY J. PRESLEY, *District Forester, Forestry Division, Missouri Conservation Commission*

There are ten State fire protection districts in Missouri. Fuel types in the areas under protection on most of the districts make it mandatory that some type of water unit be available for use in fire suppression work.

For several years the Forestry Division, Missouri Conservation Commission, has used jeep water units. The jeep tanker was first used around 1948 and additional units have been added until some districts may have as many as seven or eight in use during fire season (fig. 1). The jeep tanker has become an integral part of our fire suppression equipment.

The three basic components of the jeep tanker are the pump unit; the tank with fittings and hoses; and the half-cab jeep, on which the first two are mounted. The ¾-inch fan drive pump is mounted on the cylinder head of the jeep motor (fig. 2), and takes its power from the front end of the crankshaft through a long V-belt. Use of the additional belt is made possible by incorporating a double pulley on the crankshaft. The pump clutch (fig. 2) is operated from the dash by a flexible control rod that can be locked in the engaged position. The ¾-inch pump affords a working pressure of 135 pounds and delivers up to 25 gallons per minute of water volume at high motor speeds.

The jeep water unit provides a quick and easy means of controlling fires in fuel types where the time element is critical because of the fast rate of spread. A full load of water is carried at all times during fire season. During the spring fire season in Missouri temperatures low enough to make it necessary to drain the unit to prevent freezing are rarely encountered.


FIGURE 1.—This type of jeep tanker with L-shape tank is used extensively in fire suppression work.

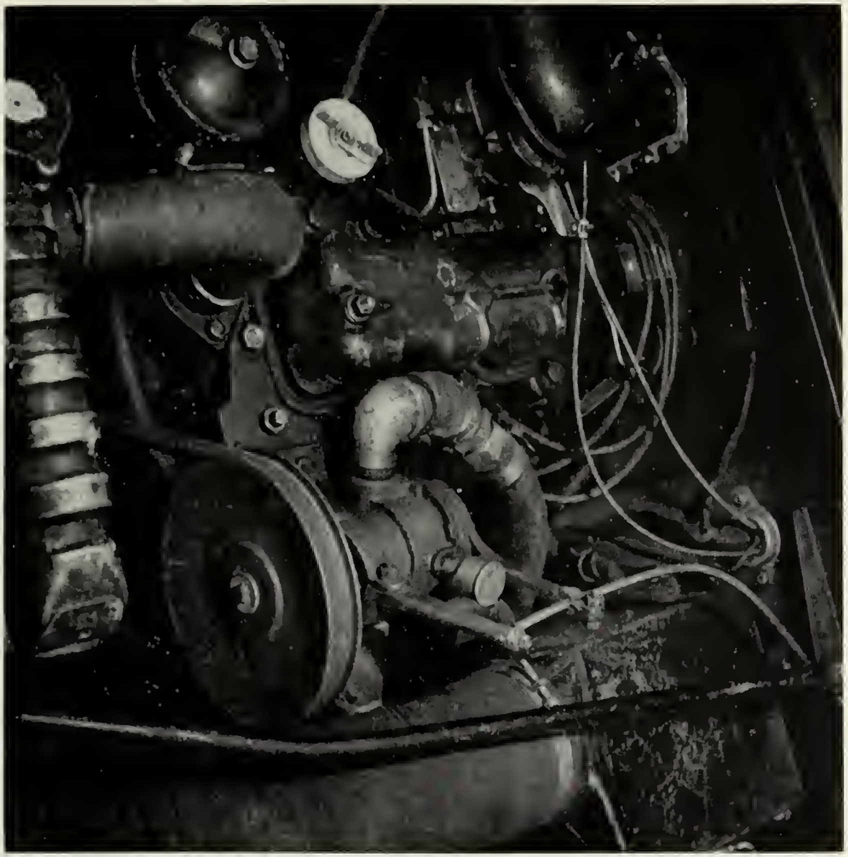


FIGURE 2.—Pump mounted on cylinder head of jeep motor, with flexible rod going through fire wall to dash mount for easy driver control.

Fires are best extinguished by 2- or 3-man crews with jeep tankers. Three-man crews are the optimum. Normally the driver operates the jeep while a second man uses the hose. The wise crew leader never tries to completely extinguish the fire (unless very small) but uses the water to cool and slow down rate of spread. A third man can follow the jeep and under most burning conditions easily control the fire with handtools or backpack pump. In some cases, the driver can operate both the vehicle and the discharge hose, thus allowing an additional man to follow with handtools.

On State Fire Protection Districts where large areas of flashy type fuels are present the jeep tanker provides (1) a quick means of attack on fires by enabling the driver in many cases to drive directly to the fire with his water supply, (2) actual suppression on small fires and a means of cooling off hot spots and heads of larger fires until additional help arrives, (3) a ready water supply for filling backpack pumps on fires where the use of the tanker itself is not practical.

## THE ROLE OF THE SOUTHWEST FIREFIGHTERS

C. K. Collins, *Forester, Southwestern Region, U.S. Forest Service*

The organized Indian firefighters from the Southwest are widely known throughout the entire West for their part in fighting major western forest fires. Actually, they are not all Indians. Part of the organized units are Spanish-American from the villages of northern New Mexico which have been inhabited since the early days of the Spaniards.

Since both the Indians and the Spanish-Americans live in or adjacent to forest areas, they have been used on forest fires in the Southwestern Region on an emergency basis for many years. In 1949, however, permanent crews were organized and trained by the Forest Service and Indian Service, and as units, began to leave the region in 1950 to help fight fires in other regions. They did so well that additional calls came for such crews the following year. As a consequence there has been a yearly increase in the use of their services by not only the Forest Service but by the other cooperating agencies such as the Bureau of Land Management, National Park Service, and Indian Service.

Each crew is composed of 25 men, including 1 crew leader, and 3 squad bosses. Each firefighter has a physical examination and an identification card. When sending crews away from New Mexico or Arizona, the agency requesting the crews will send a qualified liaison officer with each crew to handle matters of health and welfare. A regional liaison officer will also be sent to any fire where 4 or more crews will be used. He works with the fire boss or plans chief in the overall use of the crews.

In the early 1950's it was considered wise not to organize more than 500 firefighters until we could determine more about the demand for them. We considered that the men would lose interest unless used on at least 1 or 2 fires a year. We now have over 1,000 firefighters organized and ready to go any place in the United States. The critical part of the fire season in the Southwest is generally about over when other western areas are having suppression problems. As a consequence there is not too much overlap between the Southwest and other western areas in requests for the organized crews.

The Indian crews are now from the Zuni, Hopi, Santo Domingos, Jemez, Zia, Taos, Navajo, and Mescalero-Apache reservations. The Spanish-American crews are from Pecos, Penasco, Questa, and El Rito, N. Mex.

The Southwestern Region of the Forest Service, the National Park Service regional office in Santa Fe, the Bureau of Land Management office in New Mexico, the Bureau of Indian Affairs, and recently the New Mexico State Forester are cooperating in the organization and administration of the program. Annual meet-

ings are held with tribe or village officials to discuss the program with its current additions or changes.

The Forest Service does the dispatching for all the using agencies since the Forest Service uses more of the crews and probably is far better located in relation to recruiting the various units.

This service to other Forest Service regions and to other agencies outside of New Mexico and Arizona has reached a point where it has to be considered something beyond a casual venture in cooperation that could occur normally with one region helping another during a bad fire year. An analysis of the dispatching shows that it amounts to over 50 men fighting fire on the average of every single day of the year for the 6-year period 1954-59. This figure does not include the use made of the crews within the Southwestern Region of the Forest Service or by the cooperating agencies within New Mexico or Arizona, nor does it include the Forest Service or other agency personnel who accompany the crews.

Over 40,000 man-days of use were made of the organized firefighters outside the region during the months of July and August of 1960. This figure could have been much higher as we had orders at one time for about 3,000 men that could not be filled.

The question is often asked, "What do these crews have that cannot be developed in like crews from other areas?" At first glance it would appear that there is nothing special about the situation in the Southwest that could not be duplicated in other areas. However, after many years of successful use there appears to be a combination of circumstances that contribute to the overall continued success and demand for the crews. We can list them as follows:

1. Most of the Indians, such as the Zuni, Hopi, Santo Domingos, Jemez, Zias, and Taos live in pueblos or villages. Their form of government, customs, and religion tend to tie them much more closely together than the nomadic type of Indian or those who do not live in close association with one another.

2. They are taught discipline from birth.

3. They can be contacted and sent to fires in fast time considering the location of their homes.

4. They work together on their community and land projects and know how to use common tools. Many of their activities are communal in nature.

5. Their knowledge in using basic tools makes them better safety risks. The idea of doing things safely appeals to them and they learn such things fast. A safety report on their record by a California forest was received last year. A comparison was made between the organized Southwestern crews and other type firefighters and overhead on a fire. The record of the Southwestern firefighters in this case was astounding. It is especially good when the fact is considered that they do not get the easy and safe sections of fireline.

6. Due to the discipline factor they are orderly in camp and on the fire. They create no particular problem. They keep their camp

areas clean and clean up personally as well as can be expected on a fire. Their complaints are presented in an orderly way.

7. They work and stay together as a unit. They do not scatter out while in camp to a point where they cannot be assembled rapidly if needed.

8. They all live in depressed areas of the West and appreciate the work. The other units, including the Spanish-American crews, live in or near small communities where they can be recruited rapidly. These units also know they must perform as well as the Indians from the pueblos or they will not be used. As a result the competition has been keen for fire suppression work, and standards of performance have thus remained high.

## INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.


There are so Many Reasons
to Protect Your Forests
SMOKEY
Remember—
only YOU can
prevent forest fires!

VOL. 22 JANUARY 1961 No. 1



# FIRE CONTROL NOTES



A PERIODICAL DEVOTED TO THE TECHNIQUE OF FOREST FIRE CONTROL

FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

FORESTRY cannot restore the American heritage of natural resources if the appalling wastage by fire continues. This publication will serve as a channel through which creative developments in management and techniques may be communicated to and from every worker in the field of forest fire control.

Volume 22 Number 1

# FIRE CONTROL NOTES

## A Quarterly Periodical Devoted to the

## TECHNIQUE OF FOREST FIRE CONTROL

The value of this publication will be determined by what Federal, State, and other public agencies, and private companies and individuals contribute out of their experience and research. The types of articles and notes that will be published will deal with fire research or fire control management: Theory, relationships, prevention, equipment, detection, communication, transportation, cooperation, planning, organization, training, fire fighting, methods of reporting, and statistical systems. Space limitations require that articles be kept as brief as the nature of the subject matter will permit.

FIRE CONTROL NOTES is issued by the Forest Service of the United States Department of Agriculture, Washington, D. C. The matter contained herein is published by the direction of the Secretary of Agriculture as administrative information required for the proper transaction of the public business. Use of funds for printing this publication approved by the Director of the Bureau of the Budget (October 17, 1958).

Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., 20 cents a copy, or by subscription at the rate of 75 cents per year, domestic, or $1.00, foreign. Postage stamps will not be accepted in payment.

Forest Service, Washington, D. C.

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1961

# CONTENTS



NOTE: The April 1961 Fire Control Notes will emphasize Fire Suppression. Special assignments of certain articles have been made but the editor would welcome additional items on this general subject. These should reach the Washington Office by February 1.

# ALINEMENT CHART FOR PERIMETER INCREASE OF FIRES

Arthur R. Pirsko
*Forester, Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service*

An important statistic in fire control planning is the perimeter increase of a free-burning fire. Because this statistic describes what happens in the time period up to attack, or before any control action is taken, it provides a measure of the fire control job as influenced by weather, fuel, and topography. Therefore field data and computation of perimeter increase must be accurate.

One critical entry used in the California Region up to 1959 was the size of fire at discovery. The discovery size was used as the base size in computing net fire area before attack. Fire report analyses show the estimated discovery size to be so questionable that it is an invalid statistic. How accurate was a lookout's estimate of fire size when he was 15 or 20 miles from the fire? How could a lookout estimate fire size when the fire producing the smoke was on the back side of a ridge or hill? How dependable was a tourist's estimate of fire size when he stopped at a ranger station to report a fire?

In view of questions like these, the California Region is now bypassing the discovery size estimate in computing acres burned before attack. Perimeters of fires will only be calculated when the time of origin is known. Initial fire size will be assumed to be a spot or slightly larger. Rate of perimeter increase will be based on elapsed time between origin and attack.

The perimeter of a fire is a function of its shape. To find the rate at which a fire perimeter increases, we need information on shape, size, and time. Estimations by the initial attack crew as to fire shape and size must be reasonably accurate. The perimeter increase is usually expressed in chains per hour. Elapsed time can be determined rather precisely now that radio communication gives the dispatcher more exact times of attack than he had in the past.

The need for careful observation and computation was shown in a recent study correlating perimeter increase with fire-weather variables. Thousands of individual fire reports were scrutinized to see if the perimeter increase agreed with the source data of net acres and elapsed time. A high percentage of the reports failed this simple cross check. One fire, for example, was reported as having burned 2 acres in the 43 minutes before attack. The rate of perimeter increase was given as 10 chains per hour. This is impossible. The smallest perimeter for any given area is the circumference of a circle, which is 16 chains for 2 acres. To get a perimeter increase of 10 chains per hour, a typically elliptical-shaped 2-acre fire could not have been attacked in less than 2 hours and 23 minutes. If the 43 minutes is a correct entry, then the fire could only have burned 2/10 of an acre. Which entry is

incorrect? The fire planner is not in a position to judge so he is forced to discard this fire report as invalid data.

The greatest source of error, assuming size estimates to be reasonably accurate, probably is in arithmetic—in converting minutes to multiples of an hour, or in converting acres burned to chains per hour.

Hornby[1] provided some help in reducing error when he presented tables correlating fire area and perimeter by 3 shape classifications, but these tables did not help with time computations.

A simple straight line alinement chart presented here (fig. 1) takes care of the entire job. When the time from origin to attack and the acres burned in that time are known, the perimeter increase in chains per hour can be read directly from the chart.

Use the alinement chart this way:

1. Locate on the lefthand vertical column the elapsed time (in minutes) from origin to attack.
2. Locate on righthand vertical column net acres burned.
3. Lay a straightedge on the chart so it intersects the time and acres found above in steps 1 and 2. Where the straightedge crosses the middle vertical column, you will find the perimeter increase in chains per hour.

For example, given:

Origin to attack time—30 minutes. Area at attack—0.75 acre.

Then:

1. 30 minutes is located near the middle of the lefthand column.
2. Locate the 0.75 acre on the righthand column.
3. Use a straightedge to intersect the 30 minutes on the left and 0.75 acre on the right column. Where the straightedge crosses the middle column, the perimeter increase of 29 chains per hour is found.

The perimeter increase in the alinement chart is based on a fire perimeter being 1½ times the circumference of a circle. Such a perimeter relationship describes a fire shape where the length is twice the width. Hornby found that nearly all fires had a perimeter 1½ times the circumference of a circle. Experimental rate of spread tests conducted in California showed the same relationship. Exceptions occur in steep topography or when winds exceed 20 miles per hour.

These exceptions are taken care of in the Fire Shape Correction chart (fig. 2). The perimeter increase found in the alinement chart is multiplied by factors ranging from 0.67 for a circular fire to 1.33 for a flattened elliptical fire. Such correction calculations are simpler than other methods as the basic data is already converted to a length per unit time number. Correction examples are shown in figure 2.

Fire control planners will continue to need accurate base data to properly evaluate the size of the fire control job. Guides such

[1]Hornby, L. G. *Fire Control Planning in the Northern Rocky Mountain Region.* Northern Rocky Mountain Forest and Range Expt. Sta. Progress Rpt. 1, 179 pp., illus. 1936.

# SURVIVAL CLOTHING FOR FOREST-FIRE FIGHTERS

[From An Interim Progress Report by the Missoula Equipment Development Center, U. S. Forest Service.]

In cooperation with the Quartermaster Research and Engineering Command, the Forest Service has developed and tested several types of forest-fire fighter survival garments of heat-reflecting and fire-resistant materials. The Missoula Equipment Development Center, where development work has been in progress since 1959, recently tested various pilot models of fire protective clothing under burning conditions at temperatures and duration of fire believed to exceed those that would be encountered in most brush and forest fires (fig. 1).

Twelve items were placed on dummy frames at two locations within a mass fire test area of about 4 acres. Approximately 500 tons of assorted dry scrap lumber was placed in 75 piles 20 by 15 by 7 feet spaced 12 feet apart in three concentric rectangles. The corridors between rows were about 40 feet wide. The fire burned with intense heat for 2 hours (fig. 2).

Motion photographic coverage was made periodically during the fire. Films showed that the garments were subjected to intense flailing and buffeting from the fluctuating thermal air currents. They show in some cases that the garments were engulfed in flames for split-second periods. Completely adequate and reliable temperatures were not obtained because of lack of suitable

FIGURE 1.—Survival clothing located in mass fire area.

FIGURE 2.—Mass fire 20 minutes after ignition.

FIGURE 3.—Paper-foil cone before fire. Material is scrim-reinforced crepe paper laminated to 0.00035 aluminum foil. Weight, 2 pounds 10 ounces.

FIGURE 4.—Paper-foil cone after fire. Outside sustained temperature, 750 degrees. Air temperature inside garment, 300 degrees.

thermocouple equipment that would give a time-temperature history. While the temperature measurements were of a rudimentary type they nevertheless furnished relatively good information as to the durability and reflective efficiency of the garments. Maximum sustained temperatures were 188 degrees Fahrenheit 40 feet from piles, 750 degrees 12 feet away and 1800 degrees at the edge of piles.

It was found that the simplest designs, the aluminized paper cones, gowns, and bags offered more protection than the complete suits (figs. 3, 4, and 5). This might be due to the greater inside air volume since the paper-foil rigidity and more spacious design prevented them from deflecting and collapsing under erratic thermal air currents. In most instances heat energy absorption and temperature rise was less in the roomier garments. From the standpoint of reflectivity, the paper-foil laminates are equal if not better than the expensive aluminized fabrics. The aluminum surface of two fiberglass garments deteriorated under temperatures that had no damaging effect on paper-foil garments. Aluminized fabrics are more durable and will withstand flex and

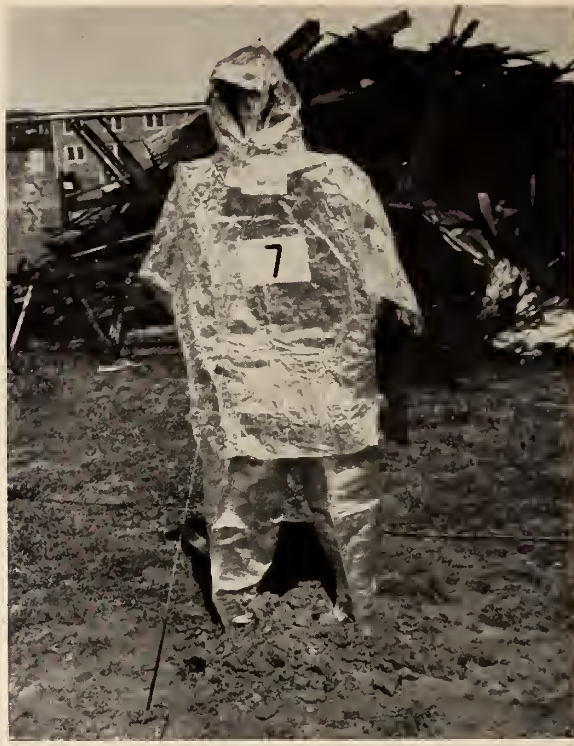



FIGURE 5.—Quartermaster Research and Engineering Command proximity suit. Material is scrim-reinforced flameproof kraft paper laminated to 0.00035 aluminum foil. Weight, 3 pounds.

tear damage better. However, it is believed that the paper-foil garments are sufficiently durable as an expendable protective garment for forest-fire fighters.

Prone or sitting positions seem to offer the best chance for survival in fire entrapment, but further tests with better instrumentation are needed to establish the best positions and procedures to be followed in emergency situations. The survival clothing development project is scheduled for completion early in 1961 at which time a project report will be published.

# WHAT DO PEOPLE KNOW ABOUT FIRE PREVENTION[1]

CRAIG C. CHANDLER, *Pacific Southwest Forest and Range Experiment Station,* and JAMES B. DAVIS, *California Division of Forestry*

You have to be carefully taught. Although this is the title to a song from a recent stage play and motion picture, it could well be the basis of our forest fire prevention effort. More and more we are finding that education is the key to success in forest fire prevention. But it must be a careful education, and we are finding that half an education may be no better than none. This is because a successful fire prevention campaign is one that does two things—

It teaches *why* we must be careful with fire.
It teaches *how* to be careful with fire.

Simple, isn't it? But the prevention man faces several problems in trying to apply these two easy maxims. The first problem in organizing a prevention campaign is how to divide the total effort between the "why" and the "how."

After this question has been answered, the prevention man faces the problem of what to teach. To catch and hold attention, information must be important, clear, and fresh. If the presentation is too technical, people are confused. Too simple or trivial information, on the other hand, can be boring or downright insulting.

These problems can be solved only if we know what the forest-using public already knows and believes about fire prevention. It becomes obvious that if we are to be good teachers we need to know a great many more facts about the people we are trying to teach.

To supply these facts is the object of research being conducted by the University of Southern California School of Public Administration under a contract with the Pacific Southwest Forest and Range Experiment Station. A recent progress report prepared by the University of Southern California staff offers some interesting reading for those concerned with forest fire prevention.[2]

This report discussed primarily the part of the research which sought to devise various kinds of questions that could be used in future surveys of the fire prevention knowledge and attitudes of various forest-using groups. Secondary aims of the study were to try various methods of administering questionnaires in the field

---

[1]Issued August 1960 by Pacific Southwest Forest and Range Experiment Station as Miscellaneous Paper 50.

[2]Herrmann, W. W. *Progress Report on Research Activities Relevant to Human Behavioral Aspects of Forest Fire Prevention.* Univ. South. Calif. School Public Admin., 188 pp. 1959. [Processed.]

and to develop a program for rapid processing of questionnaire results by electronic computers.

Eight questionnaire forms were tested. Five of these were designed for forest recreationists and three for summer home owners. Some of the forms were used by a trained interview team from the University of Southern California, some by forest fire prevention personnel with the assistance of a trained University interviewer. Still others were used by prevention personnel aided only with written instructions. The next step was the establishment of an analysis program for the computing equipment at the University.

The University of Southern California researchers now have the tools they need, including interview techniques, computing procedures, and a stockpile of questions for the next phase of the test—a large-scale survey of California hunters that should provide a definite answer to the question "What do people know about fire prevention?"[3]

In addition, an important bonus benefit was obtained from the preliminary tests. The progress report goes to some length to point out that the results of the eight test questionnaires should be accepted with caution. Each of the questionnaires was designed and administered differently. Consequently, the data could not be pooled, and no rigorous statistical treatment was possible. Nevertheless the answers are quite informative. Certain patterns of response run consistently through the whole series. A subjective appraisal of the 2,645 questionnaires that were completed shows some leads that may be of direct benefit to fire prevention program directors.

Men scored consistently better than women in fire prevention knowledge. This is hardly surprising in view of the subject matter.

People in the age bracket from 25 to 50 had the most correct information on fire prevention. Under age 25 the problem seemed to be one of lack of information, and over 50 one of misinformation.

Except among workers in lumbering and forestry, who scored consistently high, knowledge of fire prevention paralleled quite closely general educational and intellectual level as indicated by occupation. One rather disturbing fact is that agricultural occupations, which should be exposed to more fire prevention information than many other classes, scored lower than people in professional, sales, clerical, and service categories. In view of the exceptionally high level of knowledge in the lumber industry, it appears that we have failed to reach the rancher-farmer with our present fire prevention program.

Length of residence in California did not affect the scores, but length of residence in the local area had a very marked effect.

---

[3]A 2 percent survey of California hunters will be conducted by the University of Southern California School of Public Administration during 1960, using a systematic sample of hunting license records provided by the California Department of Fish and Game. This study is being financed jointly by the U. S. Forest Service and the California State Division of Forestry.

This seems to shoot holes in the often expressed idea that it is the newcomers to California who are our biggest fire problem.

Local residents had more fire prevention knowledge than visitors. Local residents who neither hunt nor fish did better on the recreationist questionnaires than did hunters from outside the area. Yet statistics on fire causes show that 60 percent of California's man-caused fires are started by local residents. It would appear that we have a situation where the local resident knows all about fire prevention but doesn't much care, while the city visitors have a very good attitude towards prevention but just don't know what to do to prevent fires.

Perhaps some of the problems implicit in the above paragraph can be explained by an analysis of the sources of information. It was immediately apparent from such an analysis that people get little "how to do it" information from the organized, mass media fire prevention campaigns. This should be accepted as a statement of fact and not an implied criticism of the mass media programs. The primary intent of any large-scale advertising program is to condition attitudes and make people aware of a product or situation, not to impart specific knowledge. In arousing a desire to "prevent forest fires," the mass media campaigns have been outstandingly successful with the audience for which they were designed.

In any event, if we exclude "common sense," an often listed source of both information and misinformation, the analysis shows that more correct and less incorrect information was obtained from talking with other people than from any other source. This seemed to be true regardless of whether the people were our own employees, parents, friends, or the gas station attendant.

Looking at the content of individual questions, one fact stood out like a sore thumb. We have apparently failed to get acceptance of the necessity for hazard reduction around buildings. This was in the top five most commonly missed questions in every questionnaire where it appeared. All the alternative answers were for clearance requirements *less* than adequate, and of the residents who answered correctly, half of them merely guessed that the largest clearance listed was the one they ought to put down.

There are two other general areas of misinformation that may be of practical importance. The California burning permit regulations were not well known by local residents. It may be argued that because nearly everyone who missed these questions thought that the requirements were more strict than they actually are, the level of knowledge in this area is no cause for concern. However, it is unlikely that anyone who believes that a burning permit is required for all fires for all 12 months of the year has ever applied for a permit. Therefore, the misinformation about permits probably means that the individuals concerned have either never needed a permit or never bothered to obtain one.

The campfire permit of the Forest Service also appears to be a subject of misinformation. About one-third of the people sampled thought the permit was valid on private as well as public land

within a national forest, and 10 percent thought it was a blanket permit, good on any land in the State.

There are other areas that may pose particular prevention problems as indicated by these preliminary surveys, but in most cases the questions need to be revised to give significant guides for action.

The six words, "You have to be carefully taught," were extremely successful for their writers. There is good reason to believe their application, guided by the facts about what people know (or don't know) about fire prevention, will be equally successful for us.

☆ ☆ ☆

## Diesel-Powered Tractor Starts Fires

Quite a few people hold the belief that diesel-powered equipment will not start fires. Unfortunately this belief has been strengthened by some unsuccessful attempts to prove that exhaust sparks from diesel engines will ignite forest fuels. We now have eyewitnesses to an actual case which will be of interest to fire control people.

On July 12, 1960, at 11:00 a.m., 4 fires were started by a diesel-powered tractor at the Missoula, Mont., airport. The tractor was equipped with a 4-yard end loader. The exhaust pipe was extended over the hood of the engine as a part of standard equipment, but there was no spark arrestor. The owner of the tractor stated that it was a 1954 model and had approximately 200 hours running time since it had been overhauled.

The machine had been idling for a short time before the operator put it in high gear and gunned the motor. He traveled a distance of 395 feet from the spot where it was idling and in this distance started four fires at intervals of 140, 90, and 130 feet. Each fire burned approximately one-tenth of an acre before it was brought under control.

The fires were observed by the writer and one other person who were on the fires immediately and started an investigation while the tractor was still near the scene of the last fire. The tracks of the tractor were plainly visible through the burned areas; the fires started within and adjacent to these tracks.

The investigation disclosed conclusively that the fires were started from hot carbon particles blown out of the exhaust and landing in flash fuels under weather conditions favorable for ignition.—E. R. De Silvia, *Chief, Division of Fire Control, Northern Region, U. S. Forest Service.*

☆ ☆ ☆

## Safety Signaling Device For Crew Trucks

A small red light mounted in the cab, about 20 feet of wire, and a push button mounted in the rear of the truck may prevent a serious accident. Its purpose is to provide a fast and positive means for the crew in the back of the truck to signal the driver in case of any emergency that might arise. With the push button mounted at a handy location it eliminates the need for a crew member to leave his seat to yell or pound on the cab to get the driver's attention. [Ed.—See also "Rear-Step Push Button for Enclosed Cab Fire Trucks" by Anne C. Holst, Fire Control Notes 17(2): 21. April 1956.]—Robert K. Hazard, *Suppression Crew Foreman, Eldorado National Forest.*

# WHAT PEOPLE THINK ABOUT FIRE LAW ENFORCEMENT[1]

JAMES B. DAVIS, *California Division of Forestry*, and CRAIG C. CHANDLER, *Pacific Southwest Forest and Range Experiment Station*

There is an old story about a farmer that had a very intelligent, hardworking mule. However, always before giving it a command he hit the mule between the eyes with a baseball bat. Not because the mule needed discipline, but because this was the only way the farmer knew to get the mule's attention.

In a sense this may be the problem that we face when we try to get compliance with forest fire laws in California. Are people paying attention to fire safety rules, and, if not, should we make more use of our legal baseball bats to insure their attention? A recent study may give us some clues.[2]

The study was conducted by the University of Southern California under contract to the Pacific Southwest Forest and Range Experiment Station. Its objective was to develop the framework for a larger scale research study to determine the attitude of the public toward law enforcement. Though primarily a search for satisfactory experimental design, this pilot test points out some important differences between violators and nonviolators as a group. The results show that the average fire law violator is an honest, intelligent citizen, well aware of the importance of fire prevention, but that we have just failed to get his attention on specific fire regulations.

Since the study sought to find differences in attitude and knowledge between fire law violators and nonviolators, Dr. Herrmann prepared two lists of persons. Names and addresses were obtained from lists of property owners on file at the Big Bear sheriff's substation, from Arrowhead District Ranger Station, and from license numbers of cars driven by forest motorists.

The names of fire law violators were taken from the law enforcement records of the San Bernardino National Forest. The violators came from 66 towns and cities throughout southern and central California. Their distribution was about what could be expected, taking into consideration population and distance, with two possible exceptions. No violators were "out-of-State" residents, and only 11 percent of the violators were forest residents despite

---

[1]Issued August 1960 by the Pacific Southwest Forest and Range Experiment Station as Miscellaneous Paper 51.

[2]Herrmann, W. W. *A Research Design for the Evaluation of Attitudinal Aspects of Fire Law Enforcement*. Univ. South. Calif. School Public Admin., 48 pp. 1960. [Processed.]

the fact that nearly half of the use and slightly more than half of the man-caused fires on the San Bernardino Forest come from local residents. Of 675 people in the combined lists, 256 nonviolators and 42 violators agreed to cooperate in the study.

Admittedly the 298 persons sampled is a very small percentage of the San Bernardino Forest's visitors, let alone California forest visitors. Yet the study can give us some pretty good ideas on how people feel about fire law enforcement in southern California. In addition it gives us some information on the makeup of the fire law violator group.

## WHAT KIND OF LAWS ARE VIOLATED?

For the most part the laws were *not* broken because of a lack of what could be called "common sense." They were rather specific regulations that needed to be learned and some of them actually involved forestry jargon or shop talk. For example, the most persistent violation concerned fire closure areas. The USC researchers found "closed area" means many things to many people.

The 138 violations were broken down in the following way:

| | |
|---|---|
| Closed area | 62 |
| Improper use of fire | 44 |
| Smoking illegally | 9 |
| Trespass | 3 |
| Miscellaneous | 20 |

The miscellaneous group includes such items as dumping hot ashes, blasting without a permit, and inadequate spark arrestors.

## DO FOREST USERS KNOW THE LAW?

Most people think that it is difficult to keep from violating fire laws. Thirty-one percent of the nonviolators and 53 percent of the violators said that they did not have enough information about laws or rules to avoid breaking them.

When asked "Do you think it is easy or difficult to get information concerning forest fire prevention rules?" both groups agreed that it was pretty difficult. Forty-two percent of the nonviolators and 48 percent of the violators thought that it was either difficult to get information or had never tried to get it.

Even more striking, 53 percent of the nonviolators and 71 percent of the violators believed that fire prevention laws are *not* known to most other people.

## WHAT DO PEOPLE THINK ABOUT FIRE LAWS?

Even though they don't know what the laws are and can't seem to find out, most people questioned think that fire laws are as important as traffic laws. This applies for both violators and nonviolators. People were definite about this point; only about 5 percent said they didn't know about the relative importance, and some of the nonviolators tended to consider fire laws even more important than traffic laws. When asked "Which would you observe more carefully?" most people said they would observe fire laws "about the same" as they would traffic laws.

## HOW DO PEOPLE FEEL ABOUT FIRE LAW ENFORCEMENT?

Reaction to enforcement depends to a degree on whether one is a violator or a nonviolator. The great majority—87 percent—of the nonviolators thought that there should be more law enforcement. The violators were not quite so positive about this; many had no opinion, but less than half thought that there should be less enforcement.

Almost all the nonviolators believed that people contacted by a forest ranger regarding a violation are treated fairly. Only 3 percent thought the treatment might be severe. Of the violators, however, 30 percent said they had not been treated fairly. Although most thought their treatment had been fair, some believed that it had been severe.

## WHO VIOLATES FOREST FIRE LAWS?

The survey indicates that most fire law violators were well-meaning persons who did not realize that they were making a mistake. However, some made "well-intentioned mistakes" outside the forest, too. When asked "Have you received any traffic citations in the past 2 years?" fire law violators answering yes outnumbered nonviolators three to one. Again, this seems to be a matter of lack of awareness, rather than disregard for law. For example, when asked to name some of the California National Forests they had visited, over half the violators named Yosemite, Joshua Tree, or other National or State parks. Only 5 percent of the nonviolators group make this mistake. Similarly, more than half of the violators said they had never seen a burned-over area even though such a sight is difficult to miss in southern California mountains.

## TO SUM IT ALL UP

We find that San Bernardino National Forest visitors and residents think that fire laws are important. However, they think that it is difficult to get enough information to keep from breaking the law.

Despite an active fire prevention program which has had a notable effect in increasing public consciousness of the fire problem, we have not been very successful in calling people's attention to the fire laws. This is particularly true with the violator group.

In forest fire prevention there appears to be a real need to improve our educational methods. The baseball bat method was the only technique the farmer knew. We hope that continued research can find a more satisfactory method for foresters.

# WHY TIE FIRE CONTROL PLANNING TO BURNING INDEX?

ARTHUR R. PIRSKO
*Forester, Pacific Southwest Forest and Range Experiment Station, U. S. Forest Service*

How many men? How much equipment? These questions are always asked when planning a fire control organization. Such questions are generally answered by a counterquery: "What values are you protecting and what burning conditions do you expect to encounter?" Experienced fire control men know that the key answer lies in an adequate description of burning conditions or expected fire behavior.

No two forest fires burn at exactly the same speed or intensity. One fire may creep through an area and burn only a part of the ground cover. On another day a fast spreading fire will burn the adjacent area clean of vegetation. If fuels and topography are almost the same in both areas, then the differences in fire behavior can be readily explained by changes in weather.

For all fire control agencies in California, the effect of changes in weather on the spread and intensity of fires is expressed in a burning index. The index is rated on a 0 to 100 scale with 0 meaning no appreciable fire spread and 100 meaning explosive spread and high intensity fires. The index tells the planner how fast the fire spreads, or in terms of job load how much fireline the initial attack crew must build to halt the forward spread of the fire. Consequently the burning index is a basic tool of fire control planning.

Given a picture of expected fire behavior, the planner designs the fire organization around initial attack crews. He also considers the resource values and the goals set up for protecting the resource unit. To protect resources for continued use, the present goal is to keep fires under 10 acres in size. Success in meeting this goal depends upon detection efficiency, plus adequate initial attack plans covering strength and speed of attack. California Region elapsed time standards for initial attack forces after discovery, which should be as soon as possible, are as follows:

| *Item* | *Elapsed Time* — *Day (minutes)* | *Elapsed Time* — *Night (minutes)* |
|---|---|---|
| Report to dispatcher: | | |
| Forest Service phone or radio | 2 | 2 |
| Other phone line | 5 | 5 |
| Fireman get-away: | | |
| Foot or car | 2 | 5 |
| Saddle horse | 5 | 10 |
| Pack horse | 10 | 20 |

Because initial attack is directed at small fires, all planning tools aim at the small size fire. Every tool, no matter how it is

designed, has one primary purpose, and also limitations of use. The burning index is no exception. It is specifically designed to measure the influence of weather alone on the spread and intensity of fires. The burning index, as an administrative tool, cannot be used as a direct measure of large fire behavior when weather is no longer the prime controller. Some high intensity fires need be only a few acres in size before they exceed the design limits of the burning index.

A key question the planner asks is "How much time does the initial attack crew have to do the job?" Time is the firefighters' biggest asset and should not be wasted. Every minute saved in attacking a fire means a reduction in the amount of fireline needed. The less fireline there is to build, the fewer number of men are needed to do the job.

The interrelationship between men, time, and burning index is illustrated in figure 1. Charts like this are used as fire planning guides in the California Region of the Forest Service to determine needed goals for strength and speed of initial attack. The charts are based on a correlation of rate of spread with the burning index as found through fire reports and weather records. In figure 1, the fuel type is second-growth pole-sized timber. For this fuel type, the fireline construction rate found by field tests is 0.5 chain (33 feet) per man-hour. The job load related to fire size at discovery can be found if the burning index is known.

How the chart is used can be shown if we assume a 0.2-acre fire is discovered on a day when the burning index is 10: Read up from burning index 10 until you intersect the 0.2-acre curve. Then read left to the vertical time axis. At this point we see that 270 minutes from now the fire will reach 10 acres in size. If a crew was at the spot, it would take 5 or 6 men to control the head of the fire and stop forward spread. Or, it would take 23 men to build a complete fireline around the fire before this 0.2-acre fire exceeded 10 acres.

But this estimate does not allow for report, get away, and travel time. If it takes 2 minutes to report the fire; 3 minutes to gather and load the crew in a truck; and 55 minutes to drive and walk to the fire, we have lost 60 minutes. The crew actually has only 210 minutes to build a fireline before the fire is over 10 acres. Eight men are needed to control the head of the fire, or 30 men to encircle the fire.

Suppose the burning index is higher, say 50. Then the 0.2-acre fire will reach 10 acres in 55 minutes. Even if the crew were on the fire at discovery time, 30 men would be needed to control the head of the fire, or 120 men to encircle it. If they were 60 minutes away, the protection goal would be lost before they arrived. To compensate for the changed burning conditions, the fire planner has two possibilities: cut travel time and add equipment to speed fireline construction.

Prompt attack buys time to do the job and is more economical than sending additional men. When burning indexes are high, the planner scatters additional crews throughout the area so that any location may be reached in less time. He avoids the pitfall of

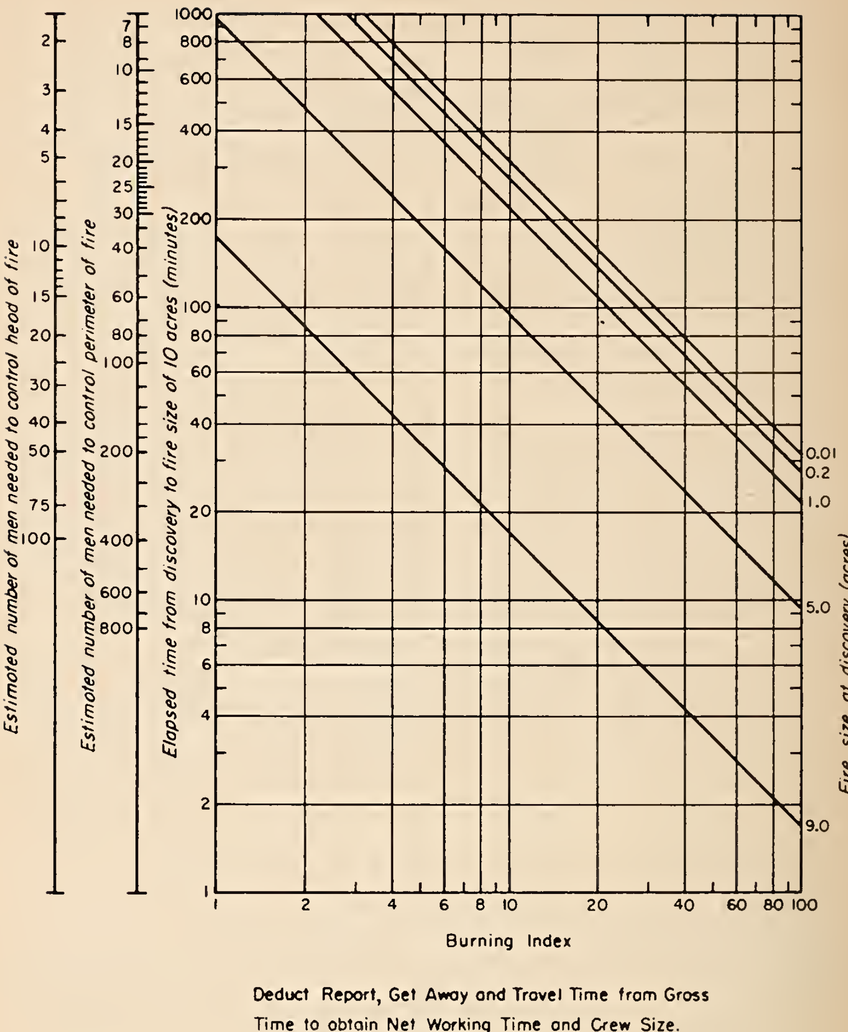



FIGURE 1.—The interrelationship between men, time, and burning index.

enlarging a 4-man crew to 10 so they would need a slow moving truck instead of a faster pickup. The planner aims at buying time rather than boosting the size of an individual crew.

When the burning index is 50, the planner need not give up because a 30-man crew is not available. He knows that the usual 60 minute discovery-to-attack time is inadequate and might plan for a 10-minute attack time. This means hiring additional crews and scattering their operating headquarters to buy time. With 10 minutes attack time, the fire will be 10 acres in size 45 minutes after the crew's arrival. It would still require 35 men to control the head of the fire. But extra men are not easy to hire, especially

for short-term jobs. The alternative is to add equipment such as pumpers, tractors, plows, or aircraft to compensate for the lack of manpower. Each piece of equipment can be evaluated as being worth so many men. The job load of the fire is then divided between men and equipment. Although such fire planning is complicated, it is unavoidable if we are to come near our resource protection goals.

To sum up, in designing the manpower and equipment requirements of a fire control organization, the planner needs information on how the fires will burn so that he can describe the potential job load. The tool he uses to evaluate fire behavior is the burning index. By considering the burning index and fire size at discovery, he can then plan for number of men plus amount and type of equipment needed to do the job.

☆ ☆ ☆

## Date Stamp Converted To Fire Prevention Use

A secretary in the office of the Montana State Forester gets credit for this idea. She proposed for all our mailing a rubber stamp that kept a running count of the fires in the State. On investigation we found that a prevention message could be included as well.

An ordinary dater was made into the fire prevention stamp. Now, all outgoing mail from the office of the Montana State Forester carries a reminder of the fire situation and a fire prevention slogan.—E. THOMAS COLLINS, *Fire Prevention Forester, Office of Montana State Forester.*

**MONTANA FOREST FIRES**
TO DATE

| Man Caused | Lightning |
| --- | --- |
| 218 | 782 |

Remember, only you can prevent Forest Fires

☆ ☆ ☆

## Marking The Way To A Fire

"Use your pressurized marking paint to mark the way in to a fire", advises Dale Thompson, Management Forester of the Sedro Wooley District, Washington State Department of Natural Resources.

"Spray yellow paint on the road, either hard surfaced or dirt. On dirt roads, the paint will last for the first 24-48 hours. That's when people are most confused and there aren't any signs. Squirts on the leaves and duff will work as well as blazes."

"Dust will cover the yellow arrow in the road or other mark in a short time, but the various men going and coming from the fire scene can remark the spot in a few seconds. And by then there'll probably be a trail to the fire."

"The nice thing about paint is that it shows up well at night—and is located in a spot where the driver is supposed to be looking—in the road!"—From "Timber Tips," *U. S. Forest Service.*

# TIME-TEMPERATURE RELATIONSHIPS OF TEST HEAD FIRES AND BACKFIRES[1]

LAWRENCE S. DAVIS and ROBERT E. MARTIN
*Southern Forest Fire Laboratory, Southeastern Forest Experiment Station*

Time-temperature relations were measured during the course of a preliminary investigation of the thermal characteristics of forest fires. Observations on 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs on the Alapaha Experimental Range near Tifton, Ga., are the basis for this report.

All burning was done on July 22, 1959, between 10 a.m. and 2 p.m., with air temperatures about 90° F. The moisture content of the upper layer of fuels, as measured by fuel-moisture sticks, decreased from 12 to 8 percent during the burning period. Winds varied from 1 to 4 miles per hour and the burning index was 1. Fuels, including litter and lower vegetation, averaged 5 to 10 tons per acre. Backfires advanced at the rate of about 1 chain per hour and head fires at the rate of 10 to 20 chains per hour. Temperature measurements were made at 3-second intervals as the fires (with about a 20-foot run) passed thermocouples located at 1- and 4-foot heights above ground.

Chromel-alumel thermocouples, when used with leads insulated with fiberglass and stainless steel mesh, were very satisfactory in these tests. Milliameters were used as measuring devices because they are relatively cheap and are readily wired and transported. Recording potentiometers would serve the purpose better but are expensive and more cumbersome to use in the field.

Composite time-temperature lines for these head and backfires are plotted on the accompanying chart (fig. 1). At the 1-foot level, the head fire temperatures rose abruptly to a maximum of about 1600° F. They then fell off, at first sharply, and then at a decreasing rate. The slower moving backfires produced temperatures from 250° to 600° F. at the 1-foot level and maintained this temperature range for several minutes. The second temperature peak associated with backfires occurred when the line of fire had passed the thermocouple, but the flames were still directed at it as a result of wind movement.

At the 4-foot level, head fire temperature peaks barely exceeded 500° F., backfire temperature peaks at the same level barely exceeded 125° F.

Lindenmuth and Byram[2] made a comparison of heat factors associated with backfires and head fires in the longleaf pine type.

---

[1]This article was presented as Southeastern Forest Experiment Station Research Notes 148 in June 1960.

[2]Lindenmuth, A. W., Jr., and Byram, G. M. Head fires are cooler near the ground than backfires. U. S. Forest Serv. Fire Control Notes 9(4): 8-9. 1948.

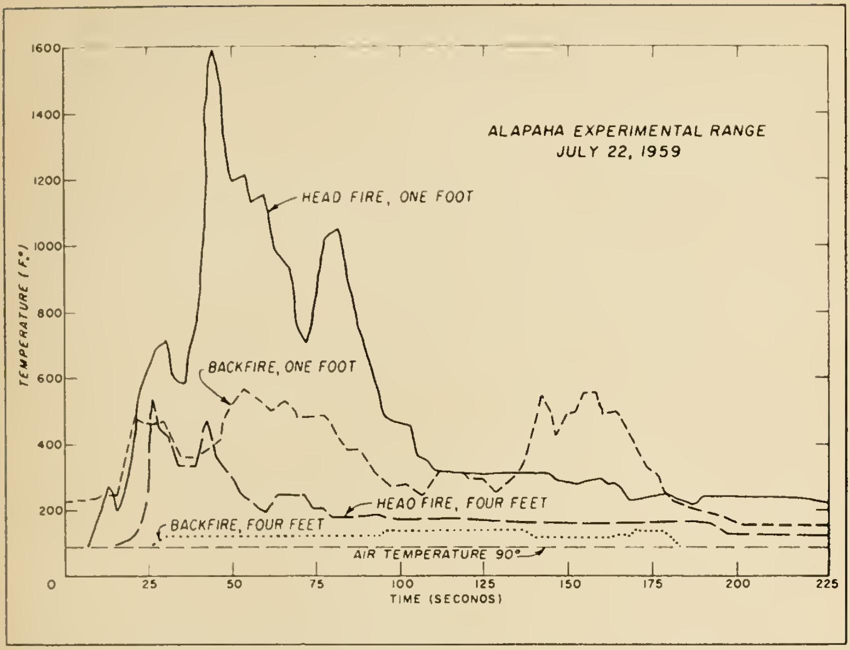



FIGURE 1.—Temperatures developed by 5 head fires and 5 backfires in 8-year-old gallberry-palmetto roughs.

In this type, which was primarily grass mixed and overlain with longleaf needles, their measurements indicated that head fires are cooler near the ground—up to 18 inches—than backfires. Our measurements do not indicate such a relationship for the gallberry-palmetto roughs, at least at the 1- and 4-foot levels. If there is a zone in this type where head fires are cooler than backfires, it is probably within a few inches of the ground.

A plot of temperature against time represents one of a fire's most significant thermal characteristics. By measuring these relationships at different heights above ground, a three-dimensional, quantitative analysis of a fire can be made which in turn can be used to rate fuels according to heat yields. Vegetation damage should be closely related to a fire's time-temperature behavior if initial vegetation temperature is taken into account.

Many more fires in different fuels under different weather conditions must be measured before the energy release that takes place in wildfires can be estimated. Detailed and carefully documented studies are now in progress at the Southern Forest Fire Laboratory.

# WEATHER AND FOREST FIRES

L. M. LaMois
*Research Forester, Division of Forest Fire Research, U. S. Forest Service*

SAN FRANCISCO, CALIF. 8-4-60
U. S. FOREST SERVICE
WASHINGTON, D. C.

FIRE SAN BERNARDINO SAYLES. CAUSE UNDETERMINED. ACRES 5564 INSIDE 1055 OUTSIDE. MEN 534 F.S. 159 STATE. CATS 3 F.S. 2 STATE. TANKERS 15 F.S. 11 STATE. 15 AIR TANKERS, 2 COPTERS. ESTIMATED TOTAL COST $225,000.

FIRE DANGER INCREASING THROUGHOUT REGION AGAIN. MOST AREAS IN HIGH AND VERY HIGH.

LOS PADRES WHITE MT. ACRES 11,900 MEN 750 10 CATS, 3 REGULAR FIXED WING PLANES 9 COPTERS 16 AIR TANKERS. ESTIMATED TOTAL FF $750,000.

TAHOE STATELINE MEN 305 TIMBER LOSS 1125 M VALUE $15,000 ESTIMATED TOTAL FF $65,000.

NORTH ZONE LIGHTNING STORM 20 FIRES YESTERDAY. STORM CONTINUED ALL NIGHT WITH SOME SCATTERED RAIN.

CENTRAL ZONE LIGHTNING STORM IN PROGRESS SEQUOIA AND SIERRA FORESTS TODAY.

ANGELES SAN DIMAS. LIGHTNING 7000 ACRES INSIDE 500 OUTSIDE, MANPOWER 260 FS 450 OTHER AGENCIES, 6 CATS, 51 TANKERS FF. TOTAL $63,750 MOST OF SAN DIMAS EXPERIMENTAL FOREST BURNED OR WILL BURN, GAS HOUSE AT HEADQUARTERS EXPLODED, MAY LOSE OTHER BUILDINGS. WINDS TURBULENT FIRE DANGER VERY HIGH.

POLECAT FIRE, 4550 ACRES, SAN GABRIEL RIVER, 1500 FIREFIGHTERS, 15 TRAILBUILDERS, 50 TANKERS, 13 AIR TANKERS, 4 HELICOPTERS. THREATENS WATERSHED. DAMAGE $4,500,000 COST $300,000. CAUSE SMOKER-FISHERMAN. ESTIMATED COST $500,000. CONTROL 50 PERCENT. WEATHER VERY HIGH FIRE DANGER.

FIRE STATE OUTSIDE LOS PADRES, 9000 ACRES, POSSIBLE THREAT. WEATHER VERY HIGH TO EXTREME.

SOUTH SIERRAS EXTREME WEATHER.

NORTH AND CENTRAL PREDICTED LIGHTNING.

Telegrams such as the above, arriving daily at the Washington Office of the Forest Service from forest regions throughout the West, reveal two unmistakable facts. The first is that the Western States suffered their worst fire experience since the early 1930's. The second is that *weather* plays the dominant role in forest fire occurrence and behavior.

The early 1960 fire experience was crucial. A prolonged period of high temperatures, low humidities, and practically no precipitation brought extremely critical burning conditions throughout the Western States during July. More than 4,000 fires occurred; most of these started from heavy concentrations of lightning storms which struck California, Oregon, Washington, Montana, and Idaho.

The far western portion of the Weather Bureau's Bulletin Highlights Map for June 1960 revealed many clues to the background for the July forest fire crises.

| | |
|---|---|
| Sacramento | One hundred percent sunshine for second consecutive June, for only 2 times since 1905. |
| Oakland | 107.1° second hottest recorded in any month. |
| Las Vegas | 87.3° average June temperature. Hottest June. |
| Pocatello | 13.7 m.p.h. average June wind speed. New June record. |
| Boise | 0.01 inch June precipitation. Driest June since 1919. |
| Lander | 61 m.p.h. wind on June 20. New June record. |
| Helena | 0.25 inch precipitation. Driest June. |
| Sheridan | January-June precipitation least since 1908. |
| Cheyenne | January-June precipitation least since 1916. |
| Winslow | 76.4° average June temperature. Hottest June. |
| Phoenix | Only trace of rain since March 2. |

How does weather affect the ways in which forest fires start and burn? All of the answers are not known yet—but what we do know is surprisingly many sided. Weather factors play a dynamic part in every stage of the forest fire problem from ignition to final control. Weather's influence can be subtle and indirect, or it can be brutal and immediate. Weather can help or hinder the firefighters. It can be an angel of mercy or a devil in disguise. Only one thing is certain—the story of a forest fire is the story of weather from the beginning to the end.

Climate usually determines the general kind and character of the vegetation that is the fire's fuel. Precipitation, relative humidity, and temperature determine how dry the fuels are and how intensely they will burn. Wind is a driving force that makes fire spread. Condition of the upper air often determines whether or not a fire will virtually make its own weather and become a heat engine which can "write its own ticket" in a blowup situation. And finally, it often is weather itself that strikes the match, in the form of lightning.

Lightning accounts for nearly 70 percent of all forest fires in the Western United States. Several factors are linked to the seriousness of lightning-started fires. First and foremost is the fact that most lightning strikes occur in the high country which is most inaccessible to firefighters. Also more often than not lightning fires occur in bunches—from 10 to 50 during a single day on a forest being not uncommon in some parts of the West. To complicate matters, the resulting fire is oftentimes at the top of a tall snag or moss-laden dead tree. Burning material from these sources are scattered by wind and slopes to the fuels below resulting in an "area ignition" pattern of considerable size. Turbulent winds accompanying thunderstorms may fan these fires to immediate problem dimensions.

Sometimes, however, lightning strikes give rise to an even more threatening situation. Here the fire is first confined to the inside of a dead snag, where it smoulders, undetected, for considerable length of time to burst forth in full bloom days later when burning conditions may be more critical than during the storm.

The flammability of the fuels in which fire starts is the key to any fire situation. Weather plays a dual role in conditioning forest

fuels. The moisture content of larger fuels such as heavy limb wood and logging slash is determined largely by amounts of precipitation over relatively long periods of time. Marked shortage of spring rain, coupled with less than normal reserves from winter snows, can set the stage for forest conflagrations during the early summer fire season. Short-term weather, however, largely controls fire occurrence through the moisture content of the lighter fuels which account for rapid spread of flame. The flammability of these flash fuels can change drastically in a matter of hours. Air temperature, relative humidity, solar radiation, and air movement combine to regulate the moisture content of dead grass, dried foliage, and small limbs or twigs on the forest floor. When severe drying conditions prevail at the end of an extended period of low precipitation the curtain is ready to be raised on the drama of major fire disaster.

On the fireline, wind plays the dominant role. Wind acts on the flame front in a double-edged manner. In addition to increasing the rate of combustion through supplying oxygen, wind action tilts the flame into unburned fuels in front of the advancing fire. With wind speeds in excess of 10–12 m.p.h., spotting from burning embers often becomes a factor in the advance of the fire front.

The air mass under which fire burns governs to a large extent the many and varied ways in which wind may influence a fire. Unstable air or the passage of a squall line may result in gustiness which will whip a fire into a fury that defies control action. The passage of a front often is accompanied by a 90° switch in wind direction; and an extended, relatively passive fire flank suddenly becomes a broad fire head, sweeping relentlessly across narrowly constructed holding lines into fresh fuels beyond.

Negative wind shear through the lower air profile can lead to the dreaded phenomenon, a "blowup." The "blowup" occurs when a lower wind speeds aloft, over the fire, and builds a strong, well-developed, convection column. In this situation a forest fire actually becomes a closed system, much like an airtight stove, in which heat energy is converted to mechanical energy in the column. This energy in turn draws in its own oxygen supply from all directions to feed the burning fuels in a "chain" reaction phenomenon, leading to the fire growing from its own power. Almost always "blowup" fires are complicated by long distance spotting. The strong convection column supports and carries aloft to great heights pieces of burning limbs and bark, often large enough to carry fire more than a mile. Because wind aloft is often different in direction from that near the ground, resulting spot fires frequently appear in deceiving locations.

As an agricultural crop, then, our Nation's timber stands deserve the full attention of our weather service. Forecasting of fire weather becomes of utmost importance to those charged with protecting our timber crop from fire. Weather reporting, also, must take into account the factors which bear so heavily upon the seasonal threats to our wood supply. The story of this July's fire tragedy in the West is written in the record of weather—weather that set the stage, drew the curtain, and provided the action on the fireline.

# GEAR CASE OILER FOR PORTABLE FIRE PUMPS

Louis F. Deyak
*Fire Control Aide, Superior National Forest*

Manufacturer's instructions for certain portable fire pumps are to fill the pilot gear case to oil level of the upper plug with a good grade of SAE 30 oil and to change oil after 10 hours of operation. After use on a fire the gear case should be refilled before storage. In storage there is usually oil seepage through the seals making for untidy conditions and necessitates checking for oil level before use on a fire. With time the essence, checking and filling to level consumes precious minutes. It is necessary to tip the pump up and pour the oil into the small plug opening. This might have to be done several times to ensure proper oil level.

To overcome these disadvantages a glass body wick-feed oiler of one ounce capacity, with the wick and center tube removed, is mounted in the upper hole of the gear case (fig. 1).

No oil is kept in the gear case or oiler during storage. At the fire and before the pump is started, the oiler is quickly filled which brings the oil to the required level. The oil can be changed while the pump is shut down or operating by the simple method of removing the lower gear case plug until the oil is drained and immediately refilled through the oiler. The oiler is protected by drilling and tapping two holes in the gear case and attaching a light metal guard with #8 x 32 screws (fig. 2).

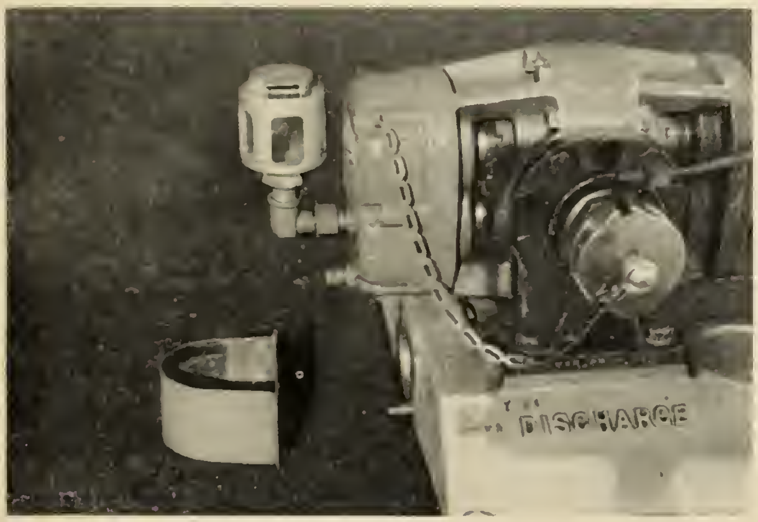


Figure 1.—Oiler mounted in upper hole of gear case.


FIGURE 2.—Guard attached to gear case.

The oiler was not installed in the lower gear case, which would give a visual reading at all times, because of (a) slowness in filling gear case, (b) erroneous reading due to surging when pump is operating, and (c) complicating the draining of the gear case.

Installation cost of oil feed, guard, fittings, and labor was $6. This method can be used on Pacific Marine Type Y, 5A7, and 5A8 pumps or any pump with the same type of gear case. Size of the oiler depends on capacity of the gear case.

☆ ☆ ☆

## Safeguarding Tanker Equipment From Freezing

A recent employee's suggestion indicated the feasibility of wrapping engines and pumpers, and vulnerable accessories, with electrical heating tape to eliminate the need of nightly drainage during freezing temperatures while tankers are still in use. An installation was made and used successfully under such conditions on the Mt. Pinos District of the Los Padres National Forest.

The installation would require approximately 20 feet of tape for a small slip-on pumper to 60 feet of tape for a large demountable tanker. Tape would have to be plugged into a 110 volt AC or DC outlet. Cost of the tape is about 25 cents per foot.

Benefits resulting from an installation when plugged in would include—

1. Removal of possibility of freezing and pumper damage if temperatures should fall below freezing during the night. Pumper damage if severe enough could put the pumper out of operation.

2. Elimination of time required to drain pumper at night and refill when needed.

3. Making starting easier and quicker.

## INFORMATION FOR CONTRIBUTORS

It is requested that all contributions be submitted in duplicate, typed double space, and with no paragraphs breaking over to the next page.

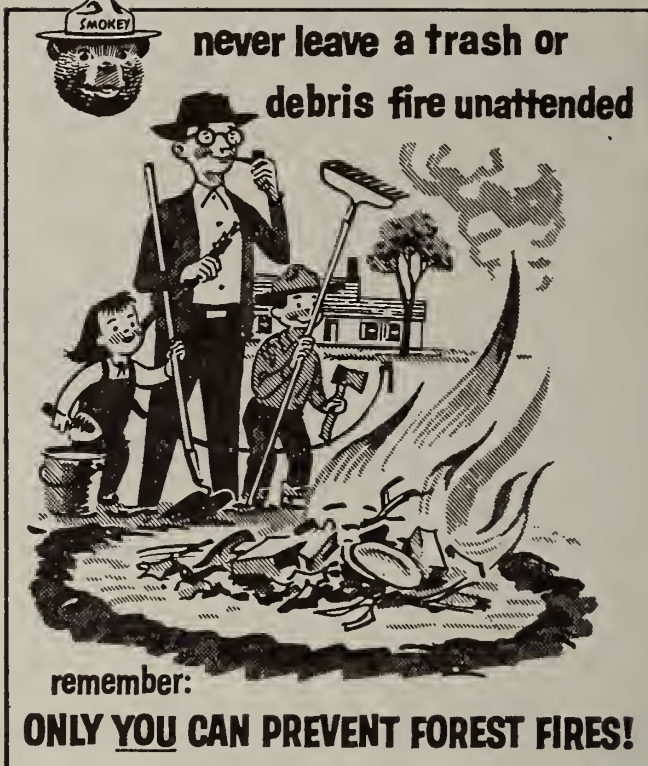
The title of the article should be typed in capitals at the top of the first page, and immediately underneath it should appear the author's name, position, and unit.

Any introductory or explanatory information should not be included in the body of the article, but should be stated in the letter of transmittal.

Illustrations, whether drawings or photographs, should have clear detail and tell a story. Only glossy prints are acceptable. Legends for illustrations should be typed in the manuscript immediately following the paragraph in which the illustration is first mentioned, the legend being separated from the text by lines both above and below. Illustrations should be labeled "figures" and numbered consecutively. All diagrams should be drawn with the type page proportions in mind, and lettered so as to permit reduction. In mailing, illustrations should be placed between cardboards held together with rubber bands. *Paper clips should never be used.*

When Forest Service photographs are submitted, the negative number should be indicated with the legend to aid in later identification of the illustrations. When pictures do not carry Forest Service numbers, the source of the picture should be given, so that the negative may be located if it is desired.

India ink line drawings will reproduce properly, but no prints (black-line prints or blueprints) will give clear reproductions. Please therefore submit well-drawn tracings instead of prints.


SMOKEY
never leave a trash or
debris fire unattended
remember:
ONLY YOU CAN PREVENT FOREST FIRES!